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WORKS OF E.J. BUTLER

FOUNDER DIRECTOR

COMMONWEALTH MYCOLOGICAL INSTITUTE

7. REPORTS

1909-20

Reports of the Imperial Mycologist in Reports of the Agricultural Research Institute and College, Pusa

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104. 1910. Report of the Director, Agricultural Research Institute and College, Pusa, for the year 1909-1910. Rep. agric. Res. Inst. Coll. Pusa, 1909-10:7-11.

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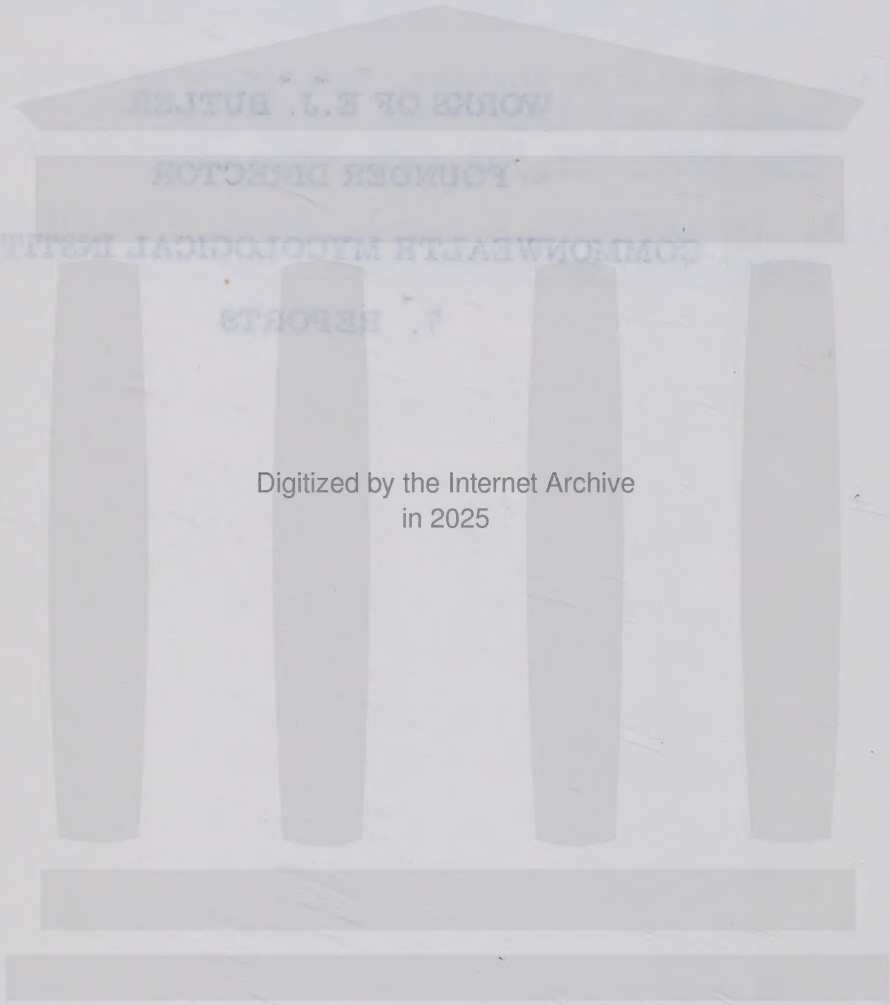

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1907/09

REPORT OF THE IMPERIAL MYCOLOGIST FOR THE YEARS 1907-09.

(E. J. Butler, M.B., F.L.S., and W. McRae,, M.A., B.Sc.)

1. *Charge and Establishment.*—The Imperial Mycologist held charge of his section till the 31st March 1909, when he proceeded on combined leave, and Mr. W. McRae, who had joined his appointment as Supernumerary Mycologist in March 1908, after a period of six months on deputation in the laboratory of Professor von Tubeuf at Munich, was appointed to officiate in his absence. The first assistant, Mr. S. K. Basu, resigned his appointment with effect from 16th December 1908. The post is not yet filled up. The appointment on probation of Mr. T. S. Lakshman Rao as assistant to the Supernumerary Mycologist, terminated on 31st March 1909, when Mr. A. Hafiz Khan, second fieldman, was promoted to the post. L. S. Subramanium, clerk on probation, was appointed third fieldman.

2. *Laboratory.*—The section moved into the new laboratories of the Phipps' Institute in June 1908. In the temporary quarters previously occupied, the work was much interfered with by dirt and insects, and the move has given much needed relief from these. When some minor improvements are carried out, the section will be well-housed in its new quarters.

3. *Training.*—A mycological assistant for the United Provinces was under training until September 1907. Another for Bombay joined in June 1908, and the Assistant Professor of Botany, Poona Agricultural College, received a short course in April and May 1908. A mycological assistant for Madras joined in November 1908, and the Mycological Collector for Eastern Bengal and Assam joined in September 1908. A student from the Central Provinces received a course in cryptogamic

botany from July to September of last year, and again in plant anatomy from November to February. Two students from the Punjab undergoing a general course in agriculture, joined on the 1st June, 1909. The Assistant Mycologist, Bengal, who returned to Pusa in March, 1908, has remained in this laboratory pending the provision of accommodation for him at Bhagalpore. The prospects of assistants in the agricultural departments appear to have been hitherto insufficient to attract good men.

4. *Organisation.*—Much time has still to be given to organising the work particularly to meet the requirements of provincial departments. Collections have to be accumulated and worked out with what voluntary assistance can be got outside India. Duplicate collections will be, as far as possible, supplied to provincial departments which already have mycological assistants. Annotated specimens of Mildews and of Ascomycetes have been sent to Mr. Salmon of Wye College and to Messrs. H. and P. Sydow of Berlin, respectively, to be worked out for extension of the general survey of Indian parasitic fungi. Collections of diseased plants received from the Central Provinces, Bengal, Bombay, Burma and Madras, have been worked out and returned, and these will be gradually extended, as further material becomes available.

In the provinces, the question of the best means of expanding mycological work was considered by the Board of Agriculture which sat at Pusa in February, 1908. A small special staff of Indian assistants to be formed in each provincial department was recommended, their duties being defined as assisting the research work of the Pusa staff and conducting the training at the colleges. The ordinary staff of agricultural assistants should undertake such practical field work in preventing diseases as is necessary. In each province there will probably be appointed one assistant professor of mycology at the college and one assistant for work outside the central station. This will form a beginning which can be extended ultimately.

Arrangements have been made for unifying the proposed mycological course in the provincial colleges, and a memorandum on a course of lectures and practical work together with the most important diseases, has been compiled as a basis for this unification of mycological teaching.

5. *Research Work.*—A small number of diseases have been selected for detailed study which, in some cases, has continued over several years. The life-history and general biology of the parasites have been studied, and information obtained of their effects on the attacked plants. The following are the chief diseases specially investigated :—

6. *Sugarcane Diseases.*—Red rot is the chief of these. The work of the period under report has been directed to elucidating the methods of infection. It has given some new results, and it is hoped to publish a further contribution to the study of this disease during the year. In the Samalkota farm red rot is now quite rare in the crop, and this may be considered due to the methods of set selection advocated by this section. Work is in progress on the life-history of two other sugarcane parasites, but so far has not reached the publication stage. A few inoculations to ascertain the mode of infection of smut proved successful and these experiments are being continued this season.

7. *Palm Diseases.*—The campaign against the palm disease of the Godaveri delta is still being prosecuted, and the entertainment of the special staff employed has been recommended for a third year. The Imperial Mycologist inspected the work in September and December 1907 and in January 1909. There has been no general recrudescence of the disease in the early months of this year, such as occurred last year, and the Imperial Mycologist was struck by the very small number of newly diseased trees seen in his tour in January last. Under the new system inaugurated in October 1908, it is hoped that cutting work will go on continuously and simultaneously over the whole of

the affected area. Successful inoculations with the parasite have been secured, and a further study of its life-history made.

A serious disease of cocoanut palms was reported from Travancore early in 1907, and the Imperial Mycologist visited the State in September and October of that year to investigate its cause. A report on the disease has since been published.

8. *Diseases of Citrus Fruits.*—The chief of these investigated were "white rust" which has appeared at Poona, and a disease which is ravaging the valuable orange orchards of Sylhet and Lower Burma. The former is identical with a disease which has recently appeared in Southern Europe. Suggestions for experimental treatment have been made. The other disease does not appear to have been previously recorded. The Imperial Mycologist visited Burma in January 1908 to investigate it, and experiments are in progress to ascertain its cause. It appears certain that it can be avoided by grafting on stalks of other citrus plants.

9. *Wilt Diseases.*—These diseases have engaged more attention during the period under report than any others. Out of the considerable number, all similar in their course, which affect economic plants in India, those of cotton, indigo, pigeon-pea and gram were selected for study. In all, the fungus to which the cotton wilt of the United States is attributed was present, and the assumption was that this fungus which is said to be a virulent parasite in America, was the responsible agent in each case Detailed experimental work has, however, thrown the gravest doubt on the parasitism of this species, and another organism was isolated from pigeon-pea which has been shown to be the cause of the disease in this crop. This organism has been called *Fusarium udum*, Butler. A memoir on the work is now in the press. The cause of the gram wilt disease has also been definitely determined, and successful infections obtained. The investigation has been lengthy and troublesome, but the diseases

referred to are amongst the most destructive in India and will well repay study. The experiments at Poona farm to raise a resistant strain of pigeon-pea, have been in progress four years and are promising well.

10. *Mulberry Disease of Kashmir.*—In a visit to Kashmir during the months of July, August and September, 1908, the Imperial Mycologist enquired into the diseases of mulberry and also those of apple, pear, peach, quince, cherry, apricot and grapevine. The results of part of this work have been published, and recommendations made for dealing with mulberry diseases. The study of the other diseases is in progress. A large collection of fungi was also made for the herbarium and these are being gradually worked out in the laboratory.

11. *Ginger Disease.*—This disease causing considerable damage in Eastern Bengal was investigated, and the probable cause of the disease determined. Experiments are still being carried out with the disease.

12. *Other Diseases of Plants.*—A new anthracnose of *val* (*Dolichos lablab*), some species of the rare genus, Choanephora, and the two maize smuts of India, have been studied, and a successful attempt has been made to work out the life-history of the very obscure paddy smut. As usual a large number of other diseases of crops were examined, and this work has formed a large portion of the routine work of the staff.

13. *Silkworm Disease.*—At the instance of the Imperial Entomologist an attempt was made to ascertain the cause of the heavy mortality amongst *eri*-silkworms during the hot weather of 1908 at Pusa. The mortality appears to be due to a specific disease allied to, but not identical with, that known as "flacherie" in ordinary silkworm.

14. *Programme for 1909-10.*—It is proposed to continue the work with sugarcane diseases and to publish a further contribution to our knowledge of red rot. If sanctioned by the Government of Madras, the palm disease campaign in the Godaveri delta will be continued. An account of

the parasite and a review of the work undertaken to prevent its spread will be published shortly.

It is hoped to complete during the year an illustrated account of the chief diseases of citrus fruit trees in India with suggestions for treatment.

It is proposed to continue the work on the wilt disease of leguminous crops, specially cow-pea, to determine the exact cause of the disease in each case.

The collection and identification of parasitic fungi will be continued. It is hoped to secure the publication of a complete list of the species of Ascomycetes in the Pusa herbarium.

It is hoped to complete the text of the book on Indian plant diseases during the year.

Students will be received for training, the regular course of instruction commencing on June 1st.

REPORT OF THE IMPERIAL MYCOLOGIST FOR THE YEAR 1909-10.

(E. J. Butler, M.B., F.L.S.)

Charge and Establishment.—Mr. W. McRae, M.A., B.Sc., Supernumerary Mycologist, held charge of the Section until December 27th, 1909, when I returned from leave. Mr. McRae joined his new appointment as Mycologist to the Government of Madras immediately after; his loss was much felt, but he has taken charge of mycological work in a province which is second to none in India in the number and magnitude of its fungus diseases of plants. His successor, Mr. F. J. F. Shaw, B.Sc., A.R.C.S., joined his appointment on January 25th, 1910. The vacant post of first assistant was filled by Mr. J. F. Dastur, B.Sc., on May 14th, 1910. Mr. J. H. Mitter, second assistant, was appointed Assistant Professor of Mycology in the Punjab Agricultural College, Lyallpur, from June 1st, 1910. The remaining members of the laboratory staff have each received promotion as a consequence. All have done good work. Messrs. J. H. Mitter and S. N. Mitra have given material assistance in the training of students and in general laboratory work; the latter, Mr. A. Hafiz Khan and Munshi Inayat Khan in field work and on tour; while Mr. Hafiz Khan, by his keenness and capacity for independent research is proving a valuable assistant. In Munshi Inayat Khan we have one of the most useful types of native botanical assistants; without any English education, he has yet an almost phenomenal knowledge of indigenous plants gathered during long service under Mr. Duthie in the Saharanpur Herbarium and as a collector in all parts of Northern India. He is in charge of the herbarium and collections, which are well kept up. The Bengal Mycological Assistant worked in the laboratory pending the provision of accommodation for him at Bhagalpur, until April 14th, 1910.

2. *Training.*—Nine students in all received instruction during the year. Of these two were second year students undergoing the full course. Their training ended on March 31st, 1910. Three were members of the Punjab Agricultural Department and received elementary instruction as part of a general agricultural course. As the Provincial Colleges are now in a position to teach elementary mycology, it is not expected that any more students of this class will be received. The student under training as Mycological Collector for Eastern Bengal finished his course on March 2nd, 1910. A Forest Ranger was deputed from the Punjab for an elementary training in the diseases of fruit and forest trees, and a private student from Oudh received a short course in fruit and vegetable diseases. Only one student (private) joined for the full two years' course at the beginning of the new term, June 1st, 1910, and he has since abandoned it. The three senior students took up about half my time in January, February, March and June, chiefly in the preparation of the lectures.

3. *Accommodation.*—The capacity of the general laboratory for students and assistants has been taxed at times, especially when several have been simultaneously engaged in original work. For a time eleven were working in the one room, which is too many for the space available. A portion of the clerk's room has been fitted to relieve pressure in the laboratory. The chief requirement at present is a small outside room with enclosure attached for inoculation and pot-culture experiments. The herbarium has been largely added to (364 named sheets), and has ample space for subsequent expansion in a room on the 1st floor. Improvements were made in the sterilising and culture rooms.

4. *Aid to Provincial Departments.*—Collections of named fungi, chiefly parasitic, have been furnished to the Madras, Punjab, Bengal and Eastern Bengal and Assam Departments. Duplicate collections made in Bombay and Burma have been identified as far as possible and the determinations forwarded to these Departments. This work

will be continued so as to provide a nucleus for a mycological herbarium in every provincial college. The detailed syllabus for an elementary course of lectures and practical work in Indian Mycology, drawn up last year, is being utilised as a basis for the mycological instruction in several colleges. The recommendation of the Board of Agriculture of 1908, that each province should have at least an Assistant Professor of Mycology and one other assistant is being worked up to fairly well. Besides Madras, which has now its own Mycologist, Mr. McRae, with one scientific assistant, Bengal, Bombay and the Punjab have each an Assistant Professor of Mycology attached to its college, the two former having a Mycological Assistant as well. The Central Provinces College has a Mycological Assistant, and Eastern Bengal a Mycological Collector. All these, except the Bombay Assistant Professor, have been trained at Pusa.

5. *Research Work. Blister Blight of Tea.*—This was the most important new work taken up during the year. The disease, which has been known for years in North-East Assam appeared for the first time in Darjeeling in 1908. In 1909 it extended, and the Darjeeling Planters' Association asked for the assistance of Pusa. Mr. McRae spent a considerable time in a local investigation of the blight. The life-history of the fungus (*Exobasidium vexans* Massee), before imperfectly known, was fully worked out and an extensive series of experiments on remedial measures undertaken. As a result of these, definite recommendations were made for the cold weather of 1909-10 and general measures for the control of the blight advocated. The results of the work were communicated in two reports to the Darjeeling Planters' Association, by which body they were printed for circulation to the planters concerned. In the present season, the blight is continuing to spread and already threatens the Dooars and Terai. Its progress will be watched with great anxiety by all interested in tea. It is feared that the climatic conditions prevalent in these districts will induce

greater virulence than anything known in Assam, but this will not be known with certainty until the close of the present or perhaps another season. A popular account of the disease is given in the Agricultural Journal of India for April, 1910, and a fuller report is in the press as a bulletin.

Other Tea Diseases.—Mr. Shaw is engaged in the study of the obscure canker of tea, which has long been known but the cause of which is still not ascertained. A disease of tea seed was investigated, but the cause was not definitely discovered.

Palm Disease.—The campaign having as its object to prevent the spread of the bud-rot of palms on the East Coast and to stamp it out within the affected area was prosecuted with energy by the executive officer in charge, Mr. W. K. Green, Special Deputy Collector, Godavari District. I accompanied Mr. McRae, to whom the scientific control has now passed, and Mr. Green on a short tour of inspection early in the present year. Recommendations for continuing the work have been made, especially for its energetic prosecution in Kistna District, where it has been neglected in spite of repeated warnings. Mr. Green was put in charge of work in Kistna as well as in Godavari from January last and this led to better work. A full account of the disease and measures taken to check it is in the press as a memoir. Mr. McRae enquired into a disease of palms at Bapatla in December but found it was not fungal. The coconut root disease in Travancore mentioned in last report is engaging the attention of the newly started Agricultural Department of that State, and measures have been taken on the lines suggested to prevent its spread. The cultivators of neighbouring districts have been warned through vernacular pamphlets of the danger of introducing certain coconut produce from Travancore.

Sugarcane Diseases.—The work in connection with these has not yet reached the stage of publication. Field experiments on the methods of infection of red rot having developed unexpected difficulties, it will probably be neces-

sary to continue in pot culture. Nothing has occurred to shake the opinion advocated by this section that it is primarily a disease conveyed in the sets and it is encouraging to report that scarcely a trace of it could be found at Samalkota Farm in the last crop. Similarly at Pusa there is ordinarily little, except near where the inoculation experiments are in progress. These results are believed to be due almost entirely to the methods of set selection recommended in 1906. There is, however, a good deal still to be elucidated. The life history of three undescribed sugarcane parasites has been in great part worked out. One causes a root disease in certain varieties of cane at Samalkota; its study has been carried out chiefly by Mr. Hafiz Khan, who has also investigated a leaf disease at Pusa. The third is prevalent in Behar. Work on sugarcane smut was continued.

Wilt-Diseases.—The results of the work of several years on the wilt disease of pigeon pea were issued as a memoir early in 1910. No opportunity arose for the study of other field crop wilts still awaiting investigation. In November, Mr. McRae visited the Wynaad at the request of the United Planters' Association of Southern India to investigate the pepper-vine wilt. He was accompanied by Mr. R. Anstead, Planting Expert to the Association, in conjunction with whom a scheme of experiments in the treatment of the disease was drawn up. As the cause, and indeed the whole history of this disease are still obscure, little advice of real value to pepper planters can be given as yet.

Ginger rot.—The investigation of this disease, caused by *Pythium gracile*, was continued by Mr. McRae, who visited Rangpur, Eastern Bengal, twice during the season. It is the principal trouble connected with ginger growing in this district and in Gujarat. It is hoped to publish an illustrated account shortly, with suggestions for treatment. Experiments so far appear to indicate that it is possible to check it by careful seed selection and rotation.

Fruit Diseases.—The survey of diseases of temperate fruit trees in India, was continued, chiefly from material

collected in Kashmir in 1908. Wither tip of citrus trees occurred at Pusa and experimental treatment was carried out. Other citrus diseases are under study at Pusa. A papaya disease which has killed a number of trees at Pusa was studied by one of the students and Mr. Mitra, but the work is not yet ready for publication.

Forest Tree Diseases.—As usual a number of these were investigated for the Forest Department and other persons. The chief of interest was *Fomes lucidus*, a probable parasite of several valuable trees including *Shisham* (*Dalbergia sissoo*) and Areca palm. An illustrated note on this was written for the "Indian Forester." The well-known parasite of the Himalayan blue pine, *Trametes Pini*, was discovered for the first time attacking deodar near Simla. Mr. Hafiz has been occupied in an attempt to determine the manner of spread of this fungus from specimens forwarded by the Imperial Forest Botanist.

Other Plant Diseases.—Two diseases caused by species of *Phytophthora* were investigated by the senior students under supervision. The life history of *Phytophthora Colocasiæ* was worked out. The other, which attacks seedling castor, appears to be undescribed previously. The work will be published after some further necessary study. Several cases of disease of important crops caused by the root-rot fungus, *Rhizoctonia*, were studied. Jute, potato, linseed, tomato, brinjal, castor and some pulses are amongst the plants attacked by this fungus, the existence of which in India has only recently been ascertained. An illustrated account of the leaf spot of turmeric, due to a new species of *Taphrina*, has been prepared for publication. Specimens of rice bunt, caused by *Tilletia horrida*, were received from Germany, on rice said to be of Indian origin. As this disease has only been reported from Japan and the Southern States an enquiry is being made as to its possible occurrence in India, especially Burma. The disease of

Para rubber trees due to *Corticium javanicum* was reported from estates in South India. Other rubber tree diseases were received from Burma. The examination of and reporting on these and many other diseases of crops and economic trees formed a large part of the routine work of the section.

Systematic work.—This was prosecuted as time allowed but the progress made was small owing to pressure of other work. As the demands from the Provincial Colleges for correct determination of their parasitic and other fungi are increasing, it is hoped to give more time to the subject than has been possible recently.

Miscellaneous.—Eight show-cases illustrating characteristic fungus diseases of plants were prepared for the Lahore Exhibition and six for the Bengal Department to exhibit at shows. Suggestions were made for regulations for the control of the importation into India of plants or parts of plants likely to introduce dangerous fungus diseases. Mr. Shaw assisted the Imperial Bacteriologist in the laboratory work in connection with Eri silk-worm disease.

Programme of work for 1910-11.—It is proposed to resume the work on soil fungi if time allows.

The work on the wilt diseases of crops, especially of indigo and cowpea and, if opportunity occurs, of cotton, gram and sesamum, will be continued.

The investigation of sugarcane diseases is being continued and the new results will be published.

It is hoped to obtain more information regarding the occurrence of *Rhizoctonia* on the crops mentioned above and to investigate its life history and treatment.

The study of the diseases of papaya, castor, colocasia and rice mentioned above, of tea canker and of heart-rot of blue pine will be continued.

The study of some anthracnoses of pulse crops will be continued.

It is hoped to work through another portion of the collections and to publish the determinations.

The training of students in Mycology will be continued. No student is taking the full course this session.

PUBLICATIONS.

Fomes lucidus (Leys) Fr., a suspected parasite. E. J. Butler. Indian Forester, September 1909.

The Wilt disease of Pigeon Pea and the Parasitism of Neocosmospora vasinfecta Smith. E. J. Butler. Memoirs of the Department of Agriculture in India, Vol. II, No. 9, January 1910.

The Outbreak of Blister-blight on Tea in the Darjeeling District in 1908-09. W. McRae. Agricultural Journal of India, Vol. V, Part 2, April 1910.

REPORT OF THE IMPERIAL MYCOLOGIST FOR THE YEAR 1910-11.

(E. J. Butler, M.B., F.L.S.)

1. *Charge and Establishment.*—I remained in charge of the section throughout the year. Mr. F. J. F. Shaw held the post of Supernumerary Mycologist. Mr. J. F. Dastur was confirmed in his appointment as first assistant. Babu P. C. Kar was appointed to the vacant post of second clerk. All the staff have worked well.

2. *Training.*—Mr. F. Fateh-ud-din, Assistant Director of Agriculture, Punjab, attended for a mycological course once a week up to April 3rd. A forest ranger from the same province received a course of training in fruit diseases up to August 13th. A private student from Bombay abandoned the course early in the year. Amongst visitors Dr. Vermoesen, Mycologist elect to the Belgian Congo, worked in the Laboratory for over two months at the end of the year.

3. *Aid to Provincial Departments.*—Collections of named fungi, chiefly parasitic, have been supplied to the Madras and Mysore mycologists. A considerable number of specimens have been named for nearly all the provinces, the largest number being for Bombay and Eastern Bengal and Assam. Advice regarding the work of Provincial assistants has been given on several occasions.

4. *Plant disease investigations.* (*a*) *Palm diseases.*—A memoir giving a full account of the bud-rot of palmyra, coco and areca palms in Madras was published in September. An organised campaign, having as its object to prevent the spread of the disease and to stamp it out within the affected area in Godavari and Kistna Districts, has been in progress since 1907. The parasite (*Pythium palmicorum*) attacks the crown of the palm only, killing the tree by destroying the growing point. Spores capable of

spreading infection from tree to tree are liberated at an advanced stage of the disease. No other method of checking this infection was found practicable than burning the diseased tops before spores had time to form. This was carried out by gangs of toddy drawers recruited by a staff of subordinate officers of the Revenue Department under the control of a special Deputy Collector. Up to the end of the financial year 1910 about half a million palms had been cut out in Godavari at a cost of some Rs. 50,000. The operations were extended to Kistna in January, 1910. The conclusions given in the memoir are as follows:—"The operations have been entirely successful in limiting the disease in Godavari District to the area previously infected. Now that they have been extended into Kistna, it is fully trusted that they will be equally successful in checking the alarming spread to the south which has been going on for some time in that direction. This alone should fully justify the cost of the operations and their continuation. It is unfortunately impossible to estimate the number of trees saved from attack within the infected area. Still the number of trees saved in those parts where the work has been longest in progress must be many thousands, and apart from preventing any extension in the Godavari District, it is not unlikely that the value of the palms actually saved within the district already exceeds the cost of the operations." Since 1910 the control of the work has passed into the hands of the recently appointed Madras Mycologist, Mr. W. McRae.

(*b*) *Tea diseases.*—A bulletin by Mr. W. McRae, on the outbreak of blister blight of tea in Darjeeling District, was published in July. This contained a more complete account of the disease than the publications on the same subject mentioned in last year's report. It is unfortunately probable that the blight has come to stay in Darjeeling as it does not seem to have appreciably diminished since its first appearance. Many planters are experimenting on the lines suggested by Mr. McRae for its control, but it is evident that effective measures will be most difficult to carry

out. A tea parasite, *Laestadia Theae*, found in Java some 12 years ago but not previously recorded in India, was reported from the Dooars in July. It causes a leaf disease, known as copper-blight, which spreads with great rapidity, but appears to be closely dependent on weather conditions. A note describing its characters was written by Mr. F. J. F. Shaw for the January number of the Agricultural Journal of India. A disease of tea seed known for many years in Assam was investigated by the Imperial Mycologist in collaboration with the officers of the Scientific Department of the Indian Tea Association. It has been shown to be probably associated with the tea seed bug, *Poecilocoris latus*, which punctures the seed and sucks the juice. Through the opening thus made fungi are able to enter, and the subsequent injury to the seed is due to the growth of one or other of several species of rot-producing fungi at the expense of the seed tissues. The Tea Association is issuing a pamphlet pointing out that this insect is probably much more injurious in seed gardens than was previously suspected and recommending measures for its destruction. Several other tea diseases were investigated during the year, in particular the stem canker, the cause of which is still obscure.

(*c*) *Soft rot of ginger.*—Mr. W. McRae published an account of this disease in the Agricultural Journal of India, April, 1911. It is prevalent in Eastern Bengal, Gujarat, and probably elsewhere. In Rangpur the loss in damp soils is 10 to 15 per cent. of the crop; in bad years almost the whole may be lost. The cause appears to be the attack of a fungus (*Pythium gracile*) on the rhizomes and base of the plant. As a result of experiments carried out at Rangpur in 1908-09, Mr. McRae was in a position to recommend effective measures for checking the disease.

(*d*) *Turmeric leaf-spot.*—This is a disease found all over Northern India, but not usually very destructive. It was found by the Imperial Mycologist to be caused by an undescribed species of *Taphrina*, and an account of it was published in the Annales Mycologici in February, 1911.

It is probably responsible for a reduction of the yield which may be much greater than the cultivators themselves suspect, but no treatment can be recommended as yet.

(*e*) *Wilt diseases.*—Experiments carried out at Pusa and independently by the Mycological Assistant of the Bombay Department at Poona, have demonstrated that the fungus which causes *rahar* (pigeon pea) wilt produces virulent spores on the stem of diseased plants. Hence it is advisable to pull out attacked plants early. Mr. Shaw has found that the cause of the death of cotton seedlings at Cawnpore is *Rhizoctonia* and not a *Fusarium* wilt. It is probable, however, that the cotton disease in the Central Provinces, Berars and other parts of India is a true wilt, and it is hoped to investigate this shortly. A gram disease resembling wilt, sent from the neighbourhood of Peshawar, was found to be caused by *Ascochyta Pisi* and not *Fusarium*. A supposed outbreak of indigo wilt which caused a good deal of alarm in September, was shown to be due to leaf-sucking insects.

(*f*) *Sugarcane diseases.*—The field experiments with red rot and *Cephalosporium* disease were abandoned as the plots became infected throughout, and were also attacked by white-ants. Successful inoculations were obtained with a fungus which causes a root disease in Madras and has not previously been described. The Bombay Department is following the recommendations of this section in introducing healthy sets into some districts where red-rot is severe.

(*g*) *Forest tree diseases.*—These continue to occupy a certain amount of time as there is no Mycologist attached to the Forest Department. The chief work of the year was the study by A. Hafiz Khan of the passage from root to root below ground of *Trametes Pini*, the fungus which causes heart rot of the blue pine. He published an account of his investigation in the *Indian Forester*, October, 1916. A serious disease of the *Nahor* (*Mesua ferrea*) has appeared in Sibsagar and Tista Divisions. It is undoubtedly caused by a fungus at the base of the tree, but we have

failed to isolate the species. A leaf disease of Piauhyensis rubber reported from Assam was identified as *Cercospora Cearae*, which has not previously been recorded on this tree. Diseases of sal, Casuarina, babul pods and deodar were also examined for the Forest Department.

(*h*) *Root-rot caused by Rhizoctonia.*—In September of last year a number of crops on the Farm were attacked by a species of *Rhizoctonia*. The crops damaged were principally groundnut, cowpea and jute, at the same time specimens of cotton seedlings from Cawnpore showed similar symptoms of disease. The fungus was isolated from each host and cross inoculations performed with a view to ascertaining whether special races of the fungus are restricted to particular hosts and the extent to which crops are liable to infection in the field. Owing to the subsequent discovery of *Rhizoctonia* on the mulberry and papaw, the scope of the work has since become extended; at present, except in the case of the *Rhizoctonia* on jute, the evidence is against the existence of special physiological races on particular hosts. A fruiting stage of the fungus was discovered on the groundnut and coincides with one which has been previously described as occurring on potatoes in America.

(*i*) *Other plant diseases.*—A disease of wheat which does not appear to resemble any hitherto described, was reported from Dharwar and Hoshangabad. It is hoped to investigate it more fully next season. The anthracnose of chillies caused by *Colletotrichum nigrum* was widespread last year, and we had several enquiries about it. Other anthracnoses examined were those of beans, sida, mango and plantain. An attack of a species of *Phytophthora* on rhea was reported from Dacca. The study of the *Phytophthora* on castor was continued. The downy mildew of *Cucurbitaceae, Plasmopara cubensis*, was found at Pusa during the year. This disease, which has been spreading gradually throughout the temperate portions of the world during the past fifteen years from centres in the United States and Japan, was not previously known in India.

The conidial stage of the *Sclerospora* on jowar was found in Bombay and supports the conclusion previously arrived at that the disease is identical with that of bajra due to *Sclerospora graminicola*. The number of parcels of specimens sent in for examination was 97, and, as usual, a large part of the routine work of the section was the identification of these; recommendations for the check of diseases caused by them were given when possible.

5. *Systematic work.*—Much time was given to this branch of the work during the year. It has been pointed out in previous reports that the accumulation of a good classified collection of Indian fungi is as necessary a part of the equipment of the section as the microscopes or other tools of the laboratory. In India, unlike more advanced countries, we have nowhere to turn to to get this work done for us. It is true that we have received generous help from specialists in other countries, but to secure this we have to undertake our share of the work. Within the past few years a large body of the *Phycomycetes*, rusts and smuts of India have been determined. The *Ascomycetes* were taken up last year, and some hundreds of specimens worked through and sent to Berlin, where the determinations will be published in collaboration with Messrs. H. and P. Sydow. Two large groups, the *Basidiomycetes* and *Deuteromycetes*, remain to be worked out, but it will not be possible to undertake their study for some years. Considerable additions to our knowledge of Indian *Phycomycetes* and rusts were also made during the year. Over 600 sheets were added to the herbarium.

6. *Miscellaneous.*—Mr. Shaw assisted the Imperial Bacteriologist in investigations of eri silkworm diseases and tobacco wilt. Eight show-cases of typical fungus diseases of plants were exhibited at the Allahabad Exhibition. A teaching collection of fungi with notes was prepared for the Elphinstone College, Bombay. A report was written on the invasion of *lantana*, a noxious weed of Mysore and Coorg, and measures for its check recommended. The

proposals made in collaboration with the Imperial Entomologist, for the legislative control of plant imports likely to introduce injurious insects and fungi into India, were printed and circulated for the consideration of Local Governments and public bodies interested, and have met with, on the whole, a favourable reception. To carry these proposals into effect will be one of the most important duties of the section in the near future. A note on the organisation of the service for the control of insect pests and fungus diseases was drawn up, also in collaboration with the Imperial Entomologist, for the International Institute of Agriculture, Rome. An outbreak of flax dodder at Pusa was dealt with, the crop being burnt. Recommendations were made to the Scientific Department of the Indian Tea Association of the best means to adopt for disinfecting tea seed intended for export, as this was insisted on in the country for which the seed was intended.

7. *Programme of work for 1911-12.*—(1) *Research and Experimental work.*—The work on the wilt diseases of crops will be continued on the lines indicated in the memoir on Pigeon-pea wilt published last year.

The investigation of the fungus diseases of sugarcane will be continued. The chief points of the present enquiry are the spread of red-rot through the soil, the relative immunity of thin canes to this disease, and the study of two undescribed cane diseases.

The study of some fruit diseases commenced last year will be continued, particularly with reference to their control by spraying.

The Supernumerary Mycologist is engaged on an investigation of the root-rot of a number of crops caused by the fungus *Rhizoctonia solani*. This will be continued.

(2) *Training.*—This will be continued on the lines indicated in the prospectus. Short courses will also be given to students taking the fruit growing and general courses and to private students, as during the past year.

(3) Advice regarding the fungus diseases of plants will continue to be given to other departments, particularly the

Provincial Departments of Agriculture and the Forest Department, and to the general public. The distribution of named specimens and other material to provincial colleges and other institutions will also be continued.

(4) The collection and identification of Indian parasitic fungi will be continued.

PUBLICATIONS.

The Bud-rot of Palms in India. E. J. Butler. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. III, No. 5, September, 1910.

A new genus of the Uredinaceae. E. J. Butler. Annales Mycologici, Vol. VIII, No. 4, 1910.

The Leaf Spot of Turmeric (Taphrina maculans n. sp.). E. J. Butler. Annales Mycologici, Vol. IX, No. 1, 1911.

Report on the Outbreak of Blister Blight on Tea in the Darjeeling District in 1908-09. W. McRae. Bulletin No. 18, Agricultural Research Institute, Pusa, July, 1910.

Soft-rot of Ginger in the Rangpur District, Eastern Bengal. W. McRae. Agricultural Journal of India, Vol. VI, No. 2, April, 1911.

Copper Blight of Tea. F. J. F. Shaw. Agricultural Journal of India, Vol. VI, No. 1, January, 1911.

Root Infection of Trametes Pini. A. Hafiz Khan. Indian Forester, October, 1910.

REPORT OF THE IMPERIAL MYCOLOGIST.

(E. J. Butler, M.B., F.L.S.)

1. *Charge and Establishment.*—I remained in charge of the section until June 16th, when I proceeded on 20 days' privilege leave, Mr. F. J. F. Shaw officiating. In addition to my own duties, I also held charge of the post of Director of the Agricultural Research Institute, Pusa, until March 31st. Mr. Shaw held the post of Supernumerary Mycologist throughout the year. Mr. J. H. Mitter, Second Assistant, reverted from the Punjab Department of Agriculture on the abolition of the post of Assistant Professor of Mycology at Lyallpur, which he had held since May 1910, on November 24th. He has again joined the Punjab Department to officiate as Assistant Professor of Botany for three months from June 15th. All the staff have worked well.

2. *Training.*—Babu K. C. Banerji, B.A., L.Ag. (Nagpur), was sent for training in Mycology and Entomology by the Bihar and Orissa Department. He attended the section from February 22nd. Lala Bishambar Das, M.Sc., Assistant Professor of Biology, Government College, Lahore, worked in the Laboratory for about six weeks during his college vacation in July and August.

3. *Aid to Provincial Departments.*—A considerable number of parasitic fungi were named for the college collections in the various Provincial Departments, especially for Bombay, Bengal and the Punjab. The manuscript of the mycological portion of a Handbook of the diseases and pests of cultivated plants in Bengal was read through and annotated. Several blocks of original figures suitable for illustrating this book were lent to the Economic Botanist, Bihar and Orissa. Some manuscripts containing results of scientific work by the Assistant Professor of Mycology and the Mycological Assistant, Poona, were read and advice given as to the best means of publishing them.

4. *Plant disease investigations.* (*a*) *Paddy diseases.*—Considerable time has been given to the investigation of a disease of inundated paddy, locally known as *ufra*, in the deltaic districts of Eastern Bengal. The disease is said by the cultivators to have existed for at least a generation, but it appears to have greatly increased in virulence in recent years, and has been under the observation of the Eastern Bengal Department of Agriculture since 1908. It was attributed by different observers to insects, fungi and unsatisfactory soil conditions. A conjoint Entomological and Mycological investigation was undertaken last December, when Mr. Fletcher, Officiating Imperial Entomologist, and myself visited Noakhali District. The result was to exclude insects as the direct cause and to throw suspicion on a worm of the Nematode class, always found living on diseased plants. This worm, a *Tylenchus*, member of a genus whose species are already known to cause several serious diseases of cereals (of which "ear-cockle" in wheat is perhaps the most familiar), is exceedingly minute, practically invisible to the naked eye; it is found in clusters, often containing many individuals, on the surface of diseased parts. The anterior end is provided with a sharp spine and a sucking apparatus, by which the juice of the living cells of the plant is made use of as nourishment. At least two, probably more, complete life cycles occur in a year and, as the female lays a large number of eggs, increase is rapid. On diseased plants the worms are found, in the early stages, occupying small brown patches on the leaves and culm. As the crop approaches maturity larger numbers of worms occur on the peduncle of the ear and just above the next lower node. At these points the stem is deep brown in colour and shrunken to little more than the thickness of a thread. Still later, worms are found within the empty glumes of the lower flowers and the ears generally bear no grain. A frequent condition is the failure of the ear to emerge from its enclosing sheath and to this the name *thor* (or swollen) *ufra* is applied, from the swollen appearance of the head of the plant. In *pucca ufra* the ears

emerge, but are light and bear no grain. In Begumganj Thana of Noakhali District about half the crop was lost last year; several fields were visited which had not been considered worth harvesting. In 1910 it is estimated that the loss in this Thana was 200,000 maunds of grain. Outside Noakhali, the disease is said to occur in Comilla, Chandpur and the neighbourhood of Dacca and is probably more widely distributed than this. The same worm was found in specimens collected in these localities and the symptoms were similar. Elsewhere, from several of the rice-growing tracts of India, reports and specimens of diseases exhibiting points of resemblance to *ufra* have been received, but examination has not, so far, revealed the occurrence of true *ufra* outside Eastern Bengal. Further work is required to ascertain if the worm must be held directly responsible for the disease and, if so, how it can be checked. Experiments in this direction are in progress in collaboration with the Bengal Department.

An unsuccessful attempt was made to trace by field inoculations the life history of the " false " smut of rice caused by *Ustilaginoidea virens*. This is being repeated this year.

(*b*) *Root rot of plants due to Rhizoctonia.*—The soil-dwelling parasite *Rhizoctonia* has been known in Europe as a fungus pest since the early part of the eighteenth century. It attacks chiefly subterranean tubers such as potato, saffron, carrot and beet; in America it is also found on cotton. The researches of the past two years, carried out by Mr. Shaw and an account of which is now in the press, have shown that, in India, it is a parasite of wide range and, in some cases, extreme virulence. The species known as *Rhizoctonia Solani* Kühn, first described in 1858 on potato, appears to be most common. It occurs on potatoes at Bankipore, and on the Pusa Farm attacks jute, groundnut and cowpea. At Cawnpore it attacks seedling cotton and it has been reported on sesame from Surat. In some cases, *e.g.*, jute and cotton, the attack takes place in the seedling stage, when it is particularly virulent, in the case of jute the death rate in pot-culture being 70 - 80 per cent. The attack on cotton

was of interest as it proved to be identical with that known in Egypt as "sore shin" and in America as "damping off," both of which diseases were attributed by their investigators to an unnamed sterile fungus.

Special attention was paid to the possibility of the existence of biologic forms within the morphological species *R. Solani*. It was found that the race on jute was markedly different in its infective power from the fungus on cowpea, groundnut and cotton. The former would only infect its own host whereas the fungus upon either of the other three hosts could infect any one of the remainder.

A second species of *Rhizoctonia*, possessing much larger sclerotia, was found on groundnut and cowpea. It soon became clear that great confusion existed in the published literature between these two forms, which have been attributed to a single species under the name *Rhizoctonia violacea* Tul. The second form also occurs sometimes on potato, where it has been identified by American writers as *R. Solani* and stated to have a Basidiomycete, *Corticium vagum*, as its perfect stage. The investigations of the last year have confirmed the latter point but have shown that the fungus associated with *Corticium vagum* is a distinct and separate species. It is suggested that the name *R. violacea* may be retained for this form.

The fact that *Rhizoctonia* may live in the soil of an infected field for years renders the disease a peculiarly difficult one to combat. In Egypt a dressing of naphthalene has been found very beneficial in the case of cotton, while in England a weak solution of carbolic acid applied to the soil has given good results. The latter method is, however, too expensive for general use. It is fortunate that, so far, cereal crops appear to be immune to this disease and a careful rotation of crops is probably the best method of lessening its ravages.

(*c*) *Wheat rust.*—Last year was marked by a severe attack of wheat rust, the first for a number of years, in the Central Provinces. The disease was also prevalent in some

other wheat-growing areas, notably in Rajputana. Munshi Inayat Khan, senior Fieldman, was deputed to collect specimens and notes in the Central Provinces at the end of March. Examination at Pusa showed that, while all three varieties of rust were present, most of the damage was caused by "orange" rust (*Puccinia triticina*) and "black" rust (*Puccinia graminis*); "yellow" rust (*Puccinia glumarum*) was much less in evidence. Previous experience indicates that, in normal years, orange rust is absent or scarce in the Central Provinces, though common in Bengal and parts of the United Provinces. It appears, therefore, that in bad years this rust extends its area and much of the losses in 1912 must be attributed to it. In breeding rust-resistant wheats for the Central Provinces, yellow rust need not at present be taken into account. Black rust is always present and does much damage even in normal years; wheats resistant to this rust would be of undoubted value. As regards orange rust, the growth of wheats which withstand this variety would be a form of insurance against the occurrence of a rusty year. It is not, unfortunately, as yet definitely known whether wheats resistant to all three rusts can be produced. Meanwhile, as it is not possible in ordinary years to study the susceptibility of Central Provinces wheats in regard to orange rust, wheats which resist this rust in localities where it is prevalent might with advantage be introduced into the province.

(*d*) *Phytophthora investigations.*—Two species of this most destructive genus of fungus parasites have been under special study in the section. The first is *Phytophthora Colocasiæ* Rac., which attacks the common indigenous vegetable *kachu* (*Colocasia antiquorum*) throughout South-Eastern Asia. Its study was commenced by Mr. G. S. Kulkarni, Mycological Assistant of the Bombay Department, when a student at Pusa in 1909. It has since been continued by myself and its successful growth in artificial culture last year has allowed of the complete working out of its life history. It is hoped to publish the result of this work shortly. Mr. Dastur, First Assistant, has taken up the study

of a *Phytophthora* which attacks castor, as part of a larger investigation of the diseases of this crop. This species has also been got into artificial culture. The simultaneous production of the saprophytic habit by artificial culture in two species of this genus, until recently supposed to be exclusively parasitic, has permitted of important additions to our knowledge of the biology of the genus. *Phytophthora infestans*, the cause of the well-known potato blight, was found attacking potatoes and tomatoes at Jorhat in Assam; on a previous occasion, in 1902, it attacked potatoes in Burdwan and Hooghly Districts in Bengal. Ordinarily confined to temperate climates and always prevalent in the Hill Tracts of India, it is, perhaps, to be feared that a race is being developed which can withstand the heat of the plains.

(*e*) *Sugar-cane diseases.*—A memoir giving the results of the work of the past few years has been commenced. The difficulties encountered in carrying on field experiments, owing to inability to control external conditions which caused the partial loss of the crop on several occasions, have led to much loss of time. A good deal of information has, however, been obtained as regards methods of infection other than by planting diseased cuttings, both in red-rot and *Cephalosporium* disease, and it is considered advisable not to delay publication. This year's work includes these two diseases and also smut. Early in 1912 specimens of a cane disease which has appeared on the Jorhat Farm were received from Mr. Meggitt, Agricultural Chemist, Eastern Bengal and Assam, who laid stress on its resemblance to *sereh*, the disease which has caused more damage in Java than probably any other of the numerous diseases of this crop. The resemblance is indeed striking and a recent visit to Jorhat has not enabled me to identify the disease with any of those known in India. The symptoms of *sereh* are elusive, its cause is unknown, its treatment very troublesome; and the accurate identification of the Jorhat disease, so that measures for its suppression may be taken if necessary, is obviously a matter of the first importance.

(*f*) *Palm diseases.*—The "plague" of betelnut palms in Bengal and Assam has continued to spread to the north and east since first reported to Sir George Watt in 1896. Since 1905, when I visited Sylhet to attempt to discover its cause, it has extended to Cachar and Goalpara. Specimens from these districts, and from Khulna at the other extremity of the affected area, were examined during the year. The cause appears to be the fungus *Polyporus* (*Fomes*) *lucidus;* this species occurs commonly on dying palms and reasons were given in 1905 for supposing it to be parasitic. More recently it has been found on diseased areca and cocoanut palms in Mysore and Ceylon, and though its parasitism has not been conclusively proved, it is considered to cause disease in both localities. The losses in North-Eastern India have been enormous, but the area affected is so large as to render impracticable any attempt to check it on the lines of the successful work against bud-rot in Madras. The application of lime has been recommended and is reported to have had a beneficial effect.

(*g*) *Tea diseases.*—Mr. Shaw visited Cachar in December to investigate tea canker. The cause of this disease still, however, remains obscure. An *Exobasidium*, closely allied to that which causes "blister blight" of tea, was discovered by Mr. I. H. Burkill in the Khasia Hills on *Camellia drupifera*, a wild relative of tea. I had some hope that this would serve to explain the spread of blister-blight from North-Eastern Assam to Darjeeling, but on submission to a specialist it was found to be a distinct species. Blister-blight was severe in parts of Assam this season and suggestions for further experiments to aid in its control were given to enquirers. The Scientific Department of the Indian Tea Association published an account of the suggested connection between the tea seed bug (*Pæcilocoris latus*) and the fungus infection of tea seed, based on work carried out by me in the previous year. The section has been freely consulted by that Department during the year.

(*h*) *Indigo disease.*—A recrudescence occurred towards the end of last season of the so called "wilt" of Java indigo

in Bihar, particularly where "moorhun" plant was kept for seed bearing. As there is much confusion between the condition due to the insect pest *Psylla* and that known as "wilt," a conjoined mycological and entomological investigation was undertaken. I visited the Research Station of the Bihar Planters' Association in November and examined the crop which had been kept for seed and which was at this date almost entirely destroyed. . No sufficient explanation of the death of the plants could be found and it appears unlikely that it is due to a definite fungus parasite. As, on the other hand, it appears to be quite clear that Psylla does not kill the plant in this fashion, it is evident that further investigation is necessary. The preliminary stages of this were commenced last year.

(*i*) *Forest tree diseases.*—A large number of specimens of diseases of forest trees were received from the Forest Department. These included various pines, deodar, shisham, teak, "nahor," *Casuarina*, "sal," "mahua," *Cassia fistula*, mulberry, etc. In several cases the diseases were due to parasites already known and suggestions for treatment could be given. In others, notably the *nahor* disease in the Sibsagar and Teesta Divisions, the cause is a fungus which it has not yet been possible to identify and no recommendations can be made.

(*j*) *Other plant diseases.*—I visited Lyallpur in October to investigate the cause of the death of cotton plants in certain areas of the Government Farm. No parasite was found but evidence was obtained to show that the damage was due to root injury, resulting from the presence of an impermeable stratum some distance below the surface of the soil. A large number of specimens of cotton plants from fourteen villages in the wilt-infected area in Berar were sent for examination by Mr. Clouston. The percentage of wilt varied from over fifty to three. *Buri* cotton, so far, remains immune and Mr. Clouston is now working out how far this advantage compensates for its lower yield as compared with the varieties commonly grown. Mr. Shaw has investigated the disease of Sisal caused by *Colletotrichum*

Agaves and has prepared a note for publication. He also visited the Sisal plantation of Messrs. Allen Brothers near Cawnpore to report on its health. An outbreak of lucerne mildew was reported from the Remount Depôt, Sargodha, and of cauliflower mildew from Lahore. Experiments were continued with a view to finding some practical method of checking anthracnose of plantains. The stem rot of papaya was also under study, as its cause has not yet been determined. Mr. Shaw made a local investigation of the orange disease in the Khasia Hills, whence the "Sylhet" oranges of the Calcutta market are exported. The cause of this very obscure disease is still unknown. Oat smut was prevalent in Behar and recommendations for its treatment have been made. A disease of coffee berries from Coorg was found to be caused by *Colletotrichum Coffeanum* Noack, a parasite which I had previously observed attacking the leaves of this plant, but which was not known to attack the berries. Mr. Shaw has commenced the study of *Striga*, a parasitic flowering plant which does much damage to sugar-cane, [illegible] other Gramineæ in India. Amongst the diseases not previously known in India, cotton anthracnose, lucerne mildew and rust of velvet beans were the chief. Two diseases of wild vines were investigated, one of which is known to attack also the cultivated species. An account of them was published since neither occurs in Europe and, if introduced, they might prove serious pests in grape-growing countries. The usual routine work of dealing with enquiries and specimens sent in for report was continued. Altogether 98 parcels of specimens were examined.

2. *Systematic work.*—A considerable advance was made in this branch of the work of the section, the additions to the named herbarium collection numbering some hundreds. These were for the most part plant parasites, about 200 additions to the parasitic flora of India having been made. The [illegible] of the list of Indian fungi which is being prepared in collaboration with Messrs. H. and P. Sydow of [illegible] were published. These [illegible] record, and in many cases also a detailed description, of over 300 species of

Indian fungi, of which more than a hundred were new to science. An account of an interesting aquatic fungus was also published. The total number of mounted sheets added to the herbarium was 779.

6. *Miscellaneous.*—I attended the meetings of a committee appointed to consider the question of preventing the importation of noxious insects and plant diseases into India, held at Pusa in November. It is greatly to be desired that action in this direction should be taken without delay. The measures recommended last year for checking the spread of lantana, a noxious weed in Mysore and Coorg, are under consideration and further information has been supplied to the authorities concerned. The section fitted up a stall at the Tirhut Agricultural and Industrial Exhibition held at Pusa in January, which was well attended. Assistance was given to the Government College, Lahore, in providing material and notes for teaching elementary mycology. An outbreak of dodder in clover was reported from Peshawar and recommendations for its suppression were made. I wrote the chapter on Mycology for the Annual Report of the Board of Scientific Advice for the year 1910-11.

7. Programme of work for 1912-13.

(*1*) *Research and experimental work.*—The investigation of the disease of paddy known as *ufra* in Bengal will be continued. Other diseases of paddy will be taken up as opportunity occurs.

Work on sugar-cane diseases will be continued. The disease which has appeared on the Jorhat Farm will be specially studied with a view to determining whether it is *sereh*.

It is proposed to examine the wilt diseases of cotton and sesame, in the Central Provinces, with a view to ascertaining their causes.

It is hoped to conclude the investigation of two species of *Phytophthora* and the diseases of castor and *Colocasia* caused by them.

The study of the so-called " wilt " of indigo will be continued.

The Supernumerary Mycologist is engaged in an investigation of some Phanerogamous plant parasites, especially *Striga*.

(*2*) *Training*.—This will be continued on the lines indicated in the Prospectus. Short courses will also be given if any students of the Institute wish to attend.

(*3*) Advice regarding the fungus diseases of plants will continue to be given to other departments, particularly the Provincial Departments of Agriculture and the Forest Department, and to the general public. The distribution of named specimens and other material to provincial colleges and other institutions will be continued.

(*4*) The collection and identification of Indian parasitic fungi will be continued.

8. Publications.

Fungi Indiæ Orientalis, Part III, H. & P. Sydow and E. J. Butler. Annales Mycologici, Vol. IX, No. 4, 1911; *ib.*, Part IV, Vol. X, No. 3, 1912.

On Allomyces, a new aquatic fungus, E. J. Butler. Annals of Botany, Vol. XXV, October 1911.

The rusts of wild vines in India, E. J. Butler. Annales Mycologici, Vol. X, No. 2, 1912.

A disease of Cotton, F. J. F. Shaw. Mufid-ul-Mazarain, September 1911 (*vernacular*).

Copper Blight of Tea, F. J. F. Shaw. Quarterly Journal of the Scientific Department, Indian Tea Association, Vol. I, Part 3, 1911 (reprint).

REPORT OF THE IMPERIAL MYCOLOGIST

(E. J. Butler, M.B., F.L.S.)

I.—Charge and Establishment.

I was on privilege leave for the first six days of the year, since when I have remained in charge of the section. Mr. F. J. F. Shaw continued to hold the post of Supernumerary Mycologist until April 21st, when he left to take up his acting appointment as Government Mycologist, Madras. He was confirmed in the service during the year. Mr. J. H. Mitter, Second Assistant, officiated as Assistant Professor of Botany in the Agricultural College, Lyallpur, until the end of August when he was appointed Assistant Professor of Botany, Muir Central College, Allahabad. The vacancy thus caused was filled by promotion in order of seniority, S. Pasupati Iyer coming in as Second Clerk. All the staff have worked well.

II.—Training.

Babu K. C. Banerji, B.A., L.Ag. (Nagpur), a stipendiary student from the Agricultural Department, Bihar and Orissa, was under training until August 17th.

III.—Diseases of Plants.

The investigation of diseases of plants caused by fungi, and the more routine work of dealing with enquiries regarding the identity and treatment of crop diseases, formed, as usual, the greater part of the work of the section.

(1) *Rice diseases.*—The disease of this crop in Eastern Bengal, locally known as *ufra*, has assumed serious proportions. The districts known to be affected are Noakhali, Tippera and Dacca. In these districts paddy is the staple food crop, occupying over 70 per cent. of the cultivated area or some $2\frac{1}{2}$ to 3 million acres, with an outturn of about

1,100,000 tons of clean rice. Both the main winter crop, or "aman," paddy and the autumn, or "aus," crop suffer, but the damage is much greater in the former, as its long growth period allows of a progressive increase of the parasite. The most severely attacked varieties are those grown in the lower lands, subject to early inundation and where transplantation is not possible. A large part of the rice grown is of this class; the transplanted varieties, grown on higher land, occupy a smaller area and do not seem to get the disease. The lower land is under water for a considerable period every year and gets little cultivation, being often allowed to remain covered with weeds and stubble after harvest until the first spring showers. The organism, an eelworm of the genus *Tylenchus*, mentioned in last year's report as the suspected cause of the disease, has been found during the year to be constantly present in every case and attempts to induce the disease experimentally by inoculating healthy paddy with it have been fully successful both at Pusa and at Dacca. The worm is one previously undescribed and, up to the present, has been found only on paddy suffering from *ufra*, or in the stubble from the diseased crop. On the living plant it is active, feeding and reproducing freely; after the death of the plant it assumes a passive condition, lying coiled up within the sheaths and glumes, and in this state can remain alive, if kept dry, for many months. Activity is resumed, at Pusa, about April. The length of the life cycle is not yet known, but there are several generations during the growth period of the crop and the rate of multiplication appears to be very considerable.

Experiments have been undertaken, in collaboration with the Bengal Department of Agriculture, to devise methods of fighting this disease. Paddy probably suffers less than any other cereal from epidemic diseases and every effort will have to be made to check the spread of *ufra*. The losses caused by it are very great; in some cases the crop is not worth harvesting, in many others it is reduced to half or a quarter of the normal. In the districts referred

to nothing else can replace paddy as a food crop, and in certain parts the distress that has been caused is undoubtedly very great. The most hopeful method of attack appears to be the destruction, by burning, of the stubble from diseased fields, and the Bengal Department has arranged to expend a considerable sum in experiments in this direction. A small area has been selected near Comilla for further experiments, especially in cultivation and trial of varieties. The enquiry will be treated as the most important on which this section is engaged, and efforts will be made in particular to fill up the gaps in our knowledge of the life history of the parasite. An account of the work up to date has been included in a Bulletin on rice diseases, now in the press, and a less technical paper has been contributed to the Agricultural Journal.

Amongst other diseases of rice investigated during the year, "bunt" (caused by *Tilletia horrida* Tak.) was found to be widely prevalent in Burma, though usually in such small amount as to cause little loss. Its detection was the result of complaints received from Germany, of the presence of black spores in rice meal imported from Rangoon and Moulmein. The disease is one which may well increase in virulence as time goes on and it is useful to know that we have a safe and assured preventative in a seed steep, similar to one employed against the allied wheat bunt.

The false smut of rice [caused by *Ustilaginoidea virens* (Cke.) Tak.] was found to occur throughout a large part of the rice-growing tracts of India. It does rather more damage than bunt, but still not enough, usually, to repay treatment. This is fortunate, for no treatment is known, and experiments to follow out the life history of the fungus and ascertain how it infects the host plant have failed. These experiments will be continued as opportunity offers.

Probably more important than either of the two last mentioned diseases is that caused by *Sclerotium Oryzæ* Catt., which I found in Burma and Madras and which also occurs at Pusa. Its symptoms are obscure and it can

easily be overlooked, as its chief effects are to cause excessive late tillering of the plant and partial sterility of the ear. Its further investigation was taken up by Mr. Shaw, who has established the parasitism of the fungus and studied its behaviour in artificial culture. The disease is probably one of the causes of the condition known in Burma as *gwa-bo*, in which an undue proportion of the ears are light or partially sterile and which is said to represent a very great aggregate loss. I found on local examination that most of the loss was attributable to insect pests, chiefly borers, and that fungus injury was probably too slight to be of economic significance. Mr. Shaw has prepared an account of his investigation, which is in the press as a Memoir.

(2) *Sugarcane diseases.*—The " red rot " of sugarcane (caused by *Colletotrichum falcatum* Went.), which is the worst fungus disease of this crop in India, has been under study at Pusa for a number of years. Various difficulties which were met with have delayed the writing up of the results, but sufficient information has now been obtained to justify publication. A Memoir, prepared jointly by myself and A. Hafiz Khan, Third Assistant, to contain the results of experimental work since 1906, has been submitted for publication. The experiments have been chiefly directed to obtain information as regards methods of infection. It has been securely established that the most common method in Northern India is by the planting of infected setts from a previously diseased crop, a method that has been recently controverted in Louisiana and the West Indies. The failure of sett selection which has been observed on several occasions, has been shown to be due to the presence, in severely diseased crops, of a percentage of infected canes which do not show the characteristic warning symptom of reddening in the pith. In attacks of ordinary severity this percentage is negligible, but in severe epidemics it is advisable to avoid the use of any cane from the diseased crop for seed. It has been further shown that sound setts may be infected after planting, though in

Northern India the parasite appears to die out rapidly in the soil and there is not much danger from this source, unless there is carelessness in allowing rotten canes to lie on the fields after harvest. Infection by air-borne spores through wounds in the stem, such as those caused by boring insects, was found to be uncommon, though accepted as the usual method in most other countries where the disease is prevalent. The leaf scars at the joints, left after the leaves are removed in stripping or wrapping the cane, are stated by some observers to admit the parasite, but it was found that this did not occur if the leaf had reached maturity and came away readily. On the other hand the shoot and root eyes at the joints can be infected and through the latter, especially, the fungus has no difficulty in gaining an entry into the cane pith. The most probable origin of the infective matter was found to be a form of the fungus which is parasitic on the midrib of the leaf, and which had been overlooked by most observers.

From these results, backed by field observations, it is concluded that the most important precaution to be taken against the disease is to select the setts used for planting, so that only those with unreddened pith are used. The effect of sett selection in keeping the disease from reaching epidemic severity has been very satisfactory in several Bihar estates and elsewhere, and it should be made a routine practice. In very severe attacks sett selection may fail, and it may be necessary to introduce new seed from outside. Care must be taken at the same time to remove early cases of the disease, in order to avoid risk of infection through the shoot and root eyes, and also to destroy rotten canes and trash after harvest, so as to prevent infection of the setts at or after the time of planting. Finally it is pointed out that the "thin" canes, in which India is so rich, are almost immune to the disease; that the comparatively little damage caused by red rot in Java may be due to the fact that many of the best Java canes are the progeny of crosses between Indian thin canes and the locally grown thick kinds; and that there is every

reason to hope that similar results can be obtained in India by hybridization.

Three minor sugarcane diseases, caused by undescribed species of fungi, have also been under study, and the work was advanced sufficiently by the end of the year to allow of the results being written up. One of these, occurring at Samalkota and Jorhat, is possibly that referred to in last year's report as resembling *sereh*. They will be more fully dealt with in the next report.

Phytophthora investigations.

Mr. J. F. Dastur, First Assistant, completed his investigations of a new species of this destructive genus, which was found attacking castor, and published a detailed description of it in the Memoirs. The parasite causes the most injurious fungal disease of this crop known, and is especially harmful to eri-silk worm breeders. On seedling plants it causes a " damping off," which may affect 30 to 40 per cent. of the seedlings; older plants are attacked chiefly in the leaves. A full account of the morphology of the parasite is given, the chief interest centring in the discovery of a new type of reproduction. Shortly before the publication of the paper, this discovery was anticipated by a British Mycologist, working with an allied species. The growth of the fungus in artificial culture was successfully attempted. A very complete series of inoculation experiments was carried out, potato, tomato, brinjal, *til* and several other plants proving susceptible to attack.

The study of *Colocasia* blight (caused by *Phytophthora Colocasiæ* Rac.) was commenced by Mr. G. S. Kulkarni, Mycological Assistant of the Bombay Department, when a student at Pusa in 1909, and completed by myself during the year. We published a joint account of it in the Memoirs, giving details of the characters of the disease and the morphology and biology of the fungus. The intensity of the attack is closely dependent on the character of the monsoon, being worst in wet years. In addition to the already known damage caused by rotting the leaves, the

parasite was found to infect the corms and to cause considerable injury after the crop is lifted. Pure cultures were grown in 1912, and a large series of inoculation experiments carried out, but the species is much more restricted in its choice of hosts than the castor parasite.

A serious outbreak of potato blight (caused by *Phytophthora infestans* de Bary) occurred in the Gangetic Plain, where the disease has not been reported since 1902. The outbreak is probably to be attributed to the fact that the local seed supply failed, in a great measure as a result of damage caused by the potato moth. A large import of hill seed occurred at the beginning of the cold weather and no doubt introduced the fungus, which is endemic in the hills. Mr. Dastur has obtained pure cultures of the parasite and is testing its temperature relations, as this appears to be likely to prove the most important factor in its control.

Rhizoctonia.

The results of Mr. Shaw's work on this genus of soil-dwelling parasites, referred to more fully in last year's report, were published during the year. He has continued his investigations, particularly with forms parasitic on lucerne and Delphinium. It is evident that great confusion of species exists in the published literature of the genus and his researches should do much to clear this up. It is of interest to record that a severe attack of opium poppy blight, which has generally been supposed to be caused by *Peronospora arborescens*, was found to be due last season to *Rhizoctonia*. It is hoped that Mr. Shaw will be able to continue his work on this, after his return from Madras.

Wheat rust.

Wheat rust was prevalent in Bihar last season and some interesting observations were made in selected areas at Pusa, on the influence of soil moisture and density of growth on the disease. Orange rust (*Puccinia triticina*)

appeared early and spread uniformly, without much relation to position in the field or density of the crop. Later on it became more intense where the crop was heaviest and tallest, but was soon masked by yellow rust (*Puccinia glumarum*). This did not appear in any quantity until the crop was nearly full grown but then developed with great intensity wherever the crop was tall and dense. Black rust (*Puccinia graminis*) was late in appearing and did not show any regularity in distribution. In February and March, Dr. Leather kindly made some determinations of soil moisture and air humidity in two plots, one with a light, thin crop where rust was slight, and the other where the crop was heavy and rust severe. The soil moisture was much better in the latter, especially from the 3rd to the 6th foot in depth. The humidity was taken within the crop, about 4 inches above ground level, the first test, lasting for 7 to 8 hours, being made on February 14th, in dull and humid weather. In the thin crop the relative humidity was 57·3 per cent. and the mean air temperature was 26° C. In the heavy, badly rusted crop, the relative humidity was 76·7 per cent. and the mean air temperature 23° C. A second test was made on February 21st, the crop having been much laid by a storm on the 15th and the day being fine with a dry west wind blowing. No appreciable difference was found in the two plots.

The intensity of the attack of yellow rust and the later stages of orange rust thus varied directly with the soil moisture and the air humidity within the crop. The early stages of orange rust would not be exposed to the influence of the latter factor, as at that period the crop is too small to cover the ground closely. By the time black rust appears, transpiration has much diminished, as the crop is almost ripe; the air temperature is higher and the dry west winds have usually set in. Hence the late rust is not much exposed to differences in air humidity. Of the two factors the immediately important one is apparently the humidity of the air within the crop, but

this again is connected with the soil moisture, as it must depend largely on the density of the crop and the vigour of transpiration.

Ground-nut diseases.

The cultivation of ground-nut in the Bombay Presidency underwent a progressive decline between 1895 and 1903. This decline was attributed in 1902 by Mr. Mollison, then Inspector General of Agriculture, to the extension of disease in the crop. In that year I found a fungal disease (caused by *Septoglœum Arachidis* Rac.) was doing great damage. Attempts to check it by spraying failed, and the only hope seemed to lie in the introduction of early maturing and resistant varieties. Recently the cultivation of ground-nut has again expanded and various reports led me to believe that this disease had diminished. On visiting the Presidency I found that this was the case to such a degree, that I had considerable difficulty in finding any attacked plants. Coincident with the decline of the disease there has been a change in the varieties of ground-nut grown. The Bombay Department of Agriculture introduced a number of foreign varieties in 1901 and the following years, and these have almost replaced the old varieties, except in the Poona District. It is difficult to avoid the conclusion that the introduction of the new varieties is connected in some way with the decline of the disease, though a direct connection is hard to establish, since the old varieties, still grown near Poona, are now equally free from attack. It would, however, be interesting to know how far natural crossing has occurred between the new and the old varieties, as in this there is a possible explanation of the difficulty. I think that Mr. Mollison and the Bombay Department are entitled to claim the credit of having successfully fought one of the worst diseases of cultivated crops which I have seen in India. The area under ground-nut in the Deccan rose from 56,000 acres in 1902-03, to nearly 200,000 acres in 1911-12.

Cotton and Sesamum wilts.

A wilt disease of cotton (caused by *Fusarium vasinfectum* Atk.) is probably the worst fungal disease of this crop in the United States and has been reported from most other cotton-growing countries. It has been known for some years that a similar disease occurs in the Central Provinces. Sesamum is also attacked by an allied disease, and an attempt was made to isolate the parasites concerned, establish their identity and make as complete a study of the diseases as possible. I found cotton wilt extends over a large area from the Central Provinces to Belgaum, being especially prevalent in the Berars, where it has been carefully observed by Mr. Clouston. Sesamum wilt extends from Hoshangabad, where Mr. Evans gave me much useful information regarding its distribution and field characters, into parts of Bombay. Fungi of the genus *Fusarium* were isolated from both crops and have been maintained in pure culture. The first attempts to test their parasitism failed, possibly because the season was already too far advanced, and the work is, consequently, being repeated.

Anthracnose of Sisal hemp.

This disease was investigated by Mr. Shaw, who established the parasitism of the fungus (*Colletotrichum Agaves* Cav.) previously suspected to be its cause. It was found to infect species of *Agave* readily and to produce a characteristic leaf disease. An account of the work was published in the Agricultural Journal of India, January 1913. Collecting and burning diseased leaves, and spraying with Bordeaux mixture, are measures which are recommended as likely to prove efficacious in checking the disease.

Indigo disease.

The work mentioned in last year's report was continued, but led to no useful results. Neither Mr. Shaw nor myself, working independently, was able to obtain any evidence that the so-called disease is caused by any definite parasite. Some half a dozen species of fungi were isolated from

plants in various stages of "disease," but none of these proved capable of reproducing it. As they were mostly belonging to the class of weak parasites, capable of infecting the host plant only when the latter has been weakened by some other agency, it was concluded that the cause of the trouble lies deeper. Since it is practically certain that it is not mycological, the enquiry was abandoned, and a note giving a summary of the work, and the reasons for this step, was submitted to the Bihar Planters' Association, and circulated amongst the members.

Forest tree diseases.

This section, as usual, assisted the Forest Department in examining and reporting on specimens of fungus diseases of forest trees, mostly received through the Imperial Forest Botanist. As this is rather a specialised branch of mycology and as the work of the section has grown too much to allow of all enquiries being dealt with equally fully, arrangements were made with the Forest Botanist, defining what assistance we were prepared to give. Under present circumstances, it will not usually be possible to undertake any definite research into the causes of undescribed diseases of trees, but where the parasite is already known, or is allied to known ones, assistance can be given. The Forest Botanist was supplied with all the information available in this section on the obscure "spike" disease of sandal.

Green parasites.

Mr. Shaw continued his investigation of the flowering plant *Striga*, which is parasitic on the roots of jowar, sugarcane and other *Gramineæ* in India. He also took up the study of an allied plant, *Sopubia*, which attacks several cereals. When the work was commenced, little was known regarding these interesting plants, but the result of work on South African species of *Striga* has recently been published. It is still necessary to compare the Indian species

with those of South Africa and the investigation of *Sopubia*, about which nothing whatever is known, is equally important. The economic aspect has not, as yet, been considered in South Africa, and this side of the enquiry is of primary interest to us.

Other plant diseases.

The section has, as usual, been consulted by the Scientific Department of the Indian Tea Association on several occasions. It was also consulted by the Australian Prickly Pear Commission, on the diseases of that plant in India, and by the Agricultural Department of British East Africa, on coffee leaf disease. A serious disease of betle pepper, which causes great loss in certain parts of India, is being investigated and appears to be caused by an undescribed species of *Colletotrichum*, of which the perfect stage has been obtained in culture. Experiments in checking anthracnose of plantains were continued. The treatment of oat smut by formalin steeping was successfully demonstrated on several estates in Bihar, and is being taken up satisfactorily. Work with *Pennisetum* smut was continued, but the life history of the fungus has not yet been worked out. A disease of maize, hitherto unknown outside Java, appeared at Pusa last year. It is exceedingly destructive in Java, but our knowledge of the life history of the parasite [*Sclerospora Maydis* (Rac.) Butl.] is imperfect and an attempt was made, and is being continued, to obtain fuller information on this point. An account of it was published in the Memoirs. The "damping off" of seedlings (caused by *Pythium de Baryanum* Hesse) was found for the first time in India last year, though common in temperate climates. Its study in culture was undertaken, and an account of it published in the Memoirs. The rotting of stored potatoes is being investigated at the instance of the Economic Botanist, Bihar and Orissa; much of the loss has been found to be due to *Rhizoctonia*,

IV.—Systematic Work.

The additions to the herbarium continued steadily, the total number of mounted sheets added being 7000. Most of these were Indian, the most important outside contributions being from Berlin and Manilla. A considerable number of parasitic fungi were named for the college collections of the Provincial Departments of Agriculture, for other colleges, and for the Forest Research Institute. Large collections of Indian fungi were distributed to interested persons. The *Hypocreaceæ* of our collections were kindly named by Mr. T. Petch, Government Mycologist, Ceylon. The perfect stages of the rusts of sugarcane, cotton and fig were discovered during the year and will be described shortly. Mr. Shaw has commenced the systematic study of some soil fungi.

V.—Programme of work for 1913-14.

(1) *Research and experimental work.*—The continued investigation of the disease of paddy, known as *ufra* in Bengal, will be regarded as the most important individual item of the work of the section. Other diseases of paddy will be studied as occasion arises.

Of sugarcane diseases, the study of which will be continued, the most important in view is the *sereh* like disease at Jorhat and elsewhere. It is hoped to ascertain definitely whether it is caused by a fungus, and, if so, whether it is identical with a new disease of which an account will shortly be published.

The wilt diseases of cotton and sesamum are major diseases, the investigation of which will be continued.

The work on potato blight may also require to be treated as an investigation of importance, if the disease again recurs, and the same applies to the opium poppy blight, referred to in the body of the report.

Besides the investigation of the last-mentioned disease, Mr. Shaw may be able, on his return from Madras, to progress with his sutdy of some green parasites, of which

a more precise knowledge than is at present available is greatly required. His work on soil fungi is likely to extend over a considerable period and is not of such immediate importance as the other enquiries, but it probably has a bearing on such questions as the decomposition of green manures, and may give valuable results.

Minor investigations are those of the anthracnoses of plantain and betle pepper, smut of *Pennisetum*, maize mildew and further work on diseases of castor.

(2) *Training.*—This will be continued on the lines indicated in the Prospectus. Short courses will also be given if any students of the Institute wish to attend.

(3) The routine work of advising on plant diseases will be continued and assistance will be given as usual to the Provincial Departments of Agriculture, the Forest Department, Planters' Associations and the general public.

(4) It is hoped to make further progress with the publication of descriptive lists of Indian fungi, and, if time permits, the preparation of a 5th part of "Fungi Indiæ Orientalis" will be taken up. This will be the most important item of the systematic work.

VI.—Publications.

1. Preliminary Report on Ufra disease of Rice in Noakhali District, E. J. Butler. *Bull. of the Bureau of Agricultural Intelligence and of Plant-diseases*, 3rd year, No. 7, July, 1912, p. 1661.

2. The Morphology and Parasitism of *Rhizoctonia*, F. J. F. Shaw. *Mem. Dept. of Agri.*, Bot. Ser., IV, No. 6, September, 1912.

3. Anthracnose of Sisal Hemp, F. J. F. Shaw. *Agri. Journ. of India*, VIII, No. 1, January, 1913.

4. Report on Mycology for 1911-12, E. J. Butler. *Annual Report of the Board of Scientific Advice*, April, 1913.

5. On *Phytophthora parasitica* nov. spec., a new disease of the Castor oil plant, J. F. Dastur. *Mem. Dept. of Agri., India*, Bot. Ser., V, No. 4, May, 1913.

6. Colocasia blight, caused by *Phytophthora Colocasiæ* Rac., E. J. Butler and G. S. Kulkarni. *Mem. Dept. of Agri., India,* Bot. Ser., V, No. 5, May, 1913.
7. *Pythium de Baryanum* Hesse, E. J. Butler. *Mem. Dept. of Agri., India,* Bot. Ser., V, No. 5, May, 1913.
8. The Downy Mildew of Maize [*Sclerospora Maydis* (Rac.) Butl.], E. J. Butler. *Mem. Dept. of Agri., India,* Bot. Ser., V, No. 5, May, 1913.
9. Diseases of Rice, E. J. Butler. *Bull. 34, Agri. Res. Inst., Pusa* (*in the press*).
10. Ufra disease of Rice, E. J. Butler. *Agri. Journ. of India,* VIII, No. 3 (*in the press*).
11. A Sclerotial disease of Rice, F. J. F. Shaw. *Mem. Dept. of Agri., India,* Bot. Ser., VI, No. 2 (*in the press*).
12. Red Rot of Sugarcane, E. J. Butler and A. Hafiz Khan. *Mem. Dept. of Agri., India,* Bot. Ser., VI, No. 5 (*in the press*).

REPORT OF THE IMPERIAL MYCOLOGIST.

(E. J. Butler, M.B., F.L.S.)

I. Charge and Establishment.

Mr. F. J. F. Shaw, B.Sc., A.R.C.S., officiated as Imperial Mycologist until November 16th, 1915, when I resumed charge of the section on return from combined leave. The post of Second Imperial Mycologist was created during the year and filled by Mr. Shaw, Supernumerary Mycologist, on October 19th, 1915. Muhammad A. Hafiz Khan, 3rd Assistant, was transferred on deputation to the Forest Research Institute, Dehra Dun, with effect from September 22nd, 1915. The vacancy thus created was filled by promotion from the staff, Babu N. C. Sen coming in as second clerk. Five of the staff volunteered for service in Mesopotamia in connection with the campaign against flies, just before the close of the year, and two of these have since been accepted. All have worked well.

II. Training and Visitors.

Babu J. B. Sinha, Fieldman in Mycology, Sabour, completed his course of training at Pusa on September 29th, 1915. Babu K. P. Roy, a scholar from the Bengal Department of Agriculture, joined on August 10th, 1915, and finished his course on May 31st, 1916. Mr. Deoki Nandan, B.A., M.R.A.C. and Mr. B. N. Vakil took special courses as private students from May 23rd and between March 15th and April 25th, respectively. Prof. K. C. Mehta, M.Sc., Professor of Botany, Agra College, worked in the section from March 3rd to 26th and Mr. G. S. Kulkarni, Mycological Assistant, Bombay, Department of Agriculture, from March 23rd to May 24th. Mr. A. C. Tunstall, Mycologist to the Indian Tea Association, visited the section from January 15th to 25th, 1916.

III. Diseases of Plants.

The investigation of the diseases of plants, the collection and identification of Indian parasitic fungi, and advice and assistance to officers of the Department and the general public, formed as usual the chief work of the section.

(1) Paddy diseases. The most important disease at present under investigation in the section is that known as "ufra" of rice, which continues to extend and attract increasing notice in Eastern Bengal. It is now throughout most of the districts of Noakhali, Tippera and Dacca and is extending into Mymensingh and probably Sylhet. With a view to testing measures for checking its ravages by experiments within the affected area, I selected a site near Comilla in 1912, and arranged for its acquisition as a temporary measure and also for complete control of its water supply by bunding, to prevent risk of infection from neighbouring fields. Subsequently it was decided by the local Department not to acquire the land, arrangements being made with the cultivators in the selected area to carry out our instructions. This did not prove satisfactory; the instructions were not followed, the bunds were defective and were cut through when water became scanty and the crop was harvested before it could be inspected. Owing to the evident difficulty of securing effective control of the selected site, it was abandoned last year and arrangements have been made to carry on the work in the neighbourhood of Dacca. Meanwhile small plots were instituted at Pusa in 1912, in order to duplicate the work under more rigorous control. It has been necessary to confine the Pusa work within narrow limits to avoid risk of the disease escaping from the plots to the surrounding cultivation; and only one or two experiments have been possible each season, outside those which could be carried on in the laboratory. The information obtained has, however, been considerable. It has been proved that a diseased plot will inevitably give a diseased crop the following year, if the stubble is allowed to rot on the ground as is the usual practice in the infected

area, but that if all the stubble is removed, a healthy crop can be grown. Furthermore it has been shown that the parasite can extend along the water courses, both with and against the stream, and infect neighbouring plots, but the distance travelled has hitherto been small. When atmospheric humidity within the crop is low, extension is hindered, but provided the humidity conditions are right, new cases of disease may become evident even on large plants within a month and many plants may be destroyed within two months of liberating the parasite in the water supply. Though under normal conditions the parasite passes into a dormant condition in the rotting stubble in the interval between successive crops (say from December to April), it can be kept in an actively parasitic state through this period by supplying it with constantly renewed young growing paddy for food, and this fact may increase our difficulties in dealing with it where the crop known as *boro* paddy is grown, fortunately a relatively small area. On present information it seems probable that the *boro* crop harbours the parasite, but that the low atmospheric humidity during the winter and spring months, when this crop is growing, checks extension and perhaps also interferes with the multiplication of the parasite. It is this same factor that doubtless explains the relatively little damage caused to the early (*aus*) crop and to the main crop in its early stages; experiments at Pusa have shown that so long as the above-ground parts of the plant are maintained dry, it is difficult to get successful infections, even though the roots and base of the plant are in mud and water, whereas during the monsoon or when inoculated plants are covered by bell jars, infection readily occurs. When insufficiently provided with moisture the parasite tends to pass into a dormant condition and ceases feeding.

Laboratory work was directed to attempts to establish conclusively that the cause of the disease is *Tylenchus angustus*, the eelworm described in Bulletin No. 34 of 1913. Attempts to obtain it in pure culture failed but conclusive proof was ultimately got by a series of experiments which

established that minute portions of infected plants were only infectious when they contained on them individuals of this species. During these experiments it was found that definite symptoms may be induced in healthy seedlings within a week when a moderate number of worms is used for inoculation. A minute strip of plant carrying, say, 20 worms can be relied on to produce the disease in covered seedlings, while a similar strip from the same plant and part but without worms, is harmless. About a hundred successful inoculations have now been carried out under conditions which leave no room for doubt that the actual parasite is this worm—perhaps the first case in which an ectoparasitic eelworm has been found causing serious injury to plants. Other points determined are that the worm is not strictly aquatic, as it perishes in some weeks if wholly immersed in water. Kept dry it lives longer, as it has the faculty of coiling itself up into a twisted knot, which will survive moderate desiccation for at least some months. It appears to be unable to grow much or moult unless supplied with its usual living food and hitherto has not been found to grow or feed on anything else than living paddy plants. On paddy it is limited to parts where the outer walls of the epidermal cells are unthickened, and in young plants penetrates the bud to reach the young leaves near the growing point as soon as possible. This position is reached not by burrowing through the tissues but entirely by passing between the folds of the bud. Several experiments were carried out to test the ability of the worm to remain alive in soil, and the results indicate that it cannot survive during the interval between successive crops in this manner.

All the work hitherto carried out confirms the conclusion previously arrived at that the parasite is normally kept alive by means of the stubble, which it is the practice in the infected area to leave on the fields after harvest. The problem of dealing with the disease therefore resolves itself into ascertaining the best way of removing or destroying this stubble. This can be done thoroughly by

raking it into heaps and burning it. It can perhaps be equally effectively carried out by early ploughing so as to bury the debris of the previous crop. Both these methods, however, are likely to interfere, if carried out on a large scale, with the local fodder supply and it seems necessary to ascertain whether diseased straw can safely be fed to cattle. There will be no need to defer active operations while such relatively minor points are being investigated, and it is hoped that the destruction of the stubble will be attempted on a large scale in the near future.

(2) "Tokra" of tobacco and mustard. The work of past two seasons has established that the parasitic species of *Orobanche* in Bihar are *O. indica* Ham. and *O. cernua* Loefll. The species *O. cernua* is the common parasite of solanaceous crops in Bihar but does not appear to attack *Cruciferæ* save in very exceptional circumstances. In a crop of mustard, grown in a field known to be badly infected with both species of Orobanche, only four cases of *O. cernua* were found among many thousands of *O. indica*. The parasitism of *O. cernua* therefore is more restricted than is that of *O. indica* which, while being a serious parasite of *Cruciferæ*, does occur to a not inconsiderable extent on *Solanaceæ*. The life histories of the two species seem to be identical, the "tokras" appearing a few weeks after the host crop is well established and rising to flower and fruit along with it. Both species rely on the production of countless millions of minute seeds for their dissemination and perennation. These seeds are present all over the cultivated lands of Bihar, their number and minute size being extremely favourable to their dispersal in the strong winds of February and March when the fruits of *Orobanche* are ripe.

Experiments were carried out during the year with a view to discovering whether the addition of quantities of sodium nitrate to crops of mustard and tobacco had any influence on the number of "tokras" which occurred in the crops. Plots of equal size were selected in land which was known to be infected with both species of *Orobanche* and

the numbers of "tokras" occurring in plots to which sodium nitrate had been added were compared with the numbers of "tokras" in plots which had not received any nitrate. A difficulty which renders the results of the first season's work on these lines somewhat inconclusive is that the number of "tokras" appearing in a plot will depend, apart from any influence of artificial manures, on the amount of "tokra" seed which the plot contained. This factor appeared in many cases to mask any effect which might have been due to the addition of sodium nitrate. The work will be continued for another year in order to eliminate this source of error but the results obtained to date do not lend any support to the view that sodium nitrate will be found a specific remedy for "tokras."

(3) **Black thread of rubber.** Work on the "black thread" disease of Hevea in Burma was continued. A popular account was published as a bulletin of the Burma Department of Agriculture and a more technical memoir is in the press. The disease first breaks out soon after the rains begin and completely disappears after the close of the monsoon. It is not fatal to the tree but does much damage by attacking the tapped area of the bark. Infected areas do not yield latex and severely diseased trees have to be excluded from the tapping round. In 1914 the loss of rubber on one estate was 2—3,000 lb. and in 1915, 8—9,000 lb., there being 12,000 trees affected in 1914 and 42,000 in 1915, out of 77,000 in tapping. The cut surface of the tapped bark becomes marked by vertical cracks, from which latex occasionally exudes; sometimes a thick cushion of coagulated latex forms below the renewing bark, causing the latter to bulge out and ultimately fall off so as to leave an open wound. The renewal of the bark is irregular, masses of callus appear on the cut surface and further tapping is hindered.

The cause of this damage is a species of *Phytophthora*, differing from the well-known canker fungus, *Phytophthora Faberi*, to which it had been attributed in the Dutch Indies. It seems to occur in Ceylon also but has been there

supposed to result from climatic conditions. In South India the same fungus is believed to be responsible for considerable damage and it is at present under study by the Madras Department.

The fungus is found both in the diseased bark and also on the fruits. It has been grown in pure culture and an extensive series of inoculations carried out both on rubber and on numerous other plants known to be attacked by species of *Phytophthora*. On rubber it is a wound parasite, being unable to infect the undamaged bark; through wounds it infects readily and produces the characteristic symptoms of the disease. Of the other plants tried, the ordinary hosts of *Phytophthora infestans*, *Ph. parasitica* and *Ph. Colocasiæ*, the three species most commonly found in Northern India, are immune, as also is cacao, one of the chief hosts of *Ph. Faberi*, and many other plants known to be liable to *Phytophthora* attack. Only on seedlings of the garden plants, *Gitis* and *Salpiglossus*, were successful infections secured.

The disease is favoured by excessive humidity and shade and is, therefore, worst in thickly planted rubber estates. The free admission of sunlight and air checks its progress, and good results may be obtained from judicious pruning and thinning. The chief source of infection seems to be the fruits, and as these have practically no value, and develop in the rains a copious growth of the parasite, from which spores are shed on the bark, it is recommended that all fruits be carefully picked and destroyed before the monsoon breaks, in infected plantations.

In continuation of the studies on allied species of this genus which have been carried on at Pusa in recent years, an account of a form of *Phytophthora parasitica* found on *Vinca rosea* has been recently submitted for publication. Germination of the durable type of spore (the oospore) has been obtained and was found to correspond in essentials with that described for *Ph. erythroseptica* in Ireland.

(4) **Opium poppy blight.** The investigation of this disease has led to the conclusion that while *Peronospora*

arborescens is a normal parasite present in almost every poppy field and probably, like most of its tribe, only epidemic under favourable climatic conditions for its spread, *Rhizoctonia* develops chiefly in fields in which the drainage is defective. The Economic Botanist, United Provinces, has discovered certain varieties which appear to be almost immune to *Peronospora* and in the growth of these and improved cultivation and drainage lies the best hope of preventing loss of the crop.

(5) *Rhizoctonia* on jute and sugarcane. Samples of jute seed from Dacca were found to contain the sclerotia of *Rhizoctonia Solani* Kühn adhering to the seed. The parasitism of this fungus upon jute has been the subject of a previous publication but up to the present *R. Solani* has been a source of damage in the region of the " collar " and has not been known to infect seed. It is not clear how this comes about and the matter will receive further investigation.

Specimens of sugarcane received from the Central Provinces were found to be infected with a sclerotial fungus. The fungus was obtained in pure culture and strongly resembled *Rhizoctonia destruens* Tass.; moreover inoculations upon *Delphinium* (the original host of *R. destruens*) and upon betle vine were successful. Further infections upon sugarcane resulted in the death of the outer leaves and of the young shoots at the base of the plant; the infections are still progressing at the moment of writing. In the field the fungus causes a bright red spot on the leaf sheath and this is the first noticeable result in artificial infections. In badly diseased specimens the leaf bases are dark red and have a fibrous appearance as if the parenchyma had been rotted away leaving the vascular bundles. On stripping the leaf bases the stem has a pale pink colour under the epidermis and in section the interior shows a generally diffused salmon pink colour partly obscured by a thick white felt of hyphæ. The mycelium shows a tendency to form strands of hyphæ in a manner suggestive of *R. destruens*. Further research is in progress.

(6) Anthracnose of peppers. The disease of betle pepper referred to in previous reports as being probably due to an anthracnose fungus, has proved more difficult to elucidate than was anticipated. All attempts to produce it artificially by inoculating with cultures of the suspected fungi have failed. In the absence of definite knowledge of the cause no useful recommendations for treatment can be offered.

The chilli anthracnose (due to *Colletotrichum nigrum*) is a serious disease of this crop in several parts of India. It was prevalent in Bihar last year and some spraying experiments were tried. Later on it appeared that a more hopeful line of treatment lay in the use of disease-free seed and investigations are in progress to test this method. It has been found that, as in the allied bean anthracnose, the parasite penetrates the pod and reaches the seed. If such seed be sown the following season a certain number germinate and give seedlings on which the fungus may be found. Such seedlings must serve as a source of infection to their neighbours and it seems probable that this is one of the main ways by which the disease is perpetuated. If seed only from healthy pods be used this source of infection can be eliminated, and further experiments are in progress to test the effect of this on the subsequent crop.

(7) Plantain diseases. An account of a plantain disease prevalent at Pusa was published early in the year. It is a wilt, caused by a species of *Fusarium* allied to, but distinct from, that which causes the dreaded Panama disease of the New World. The parasite was grown in pure culture and successful inoculations with it secured. In mild attacks the growth of the plant is not checked but in more severe cases the rot reaches the stem and may kill the whole crown. Much loss is also caused when the stalk of the fruit bunch becomes attacked as this may lead to total destruction of the bunch. No method of treatment has been found.

A second plantain disease, familiar in India, is the fruit rot caused by *Glocosporium musarum*. Attempts to

check this by spraying have been in progress for a considerable time. It has been found that early spraying with Burgundy mixture, beginning in June and repeated every fortnight until the fruit is nearly ripe, when ammoniacal copper carbonate should be used, is successful in preserving the fruit from the disease. An account of the method has been published.

(8) Sal tree disease. The disease of sál trees, mentioned for the first time in the last annual report of the section, has appeared again this year in the forest of Buxa Duars and is also reported in the Gorakhpur division. The symptoms of the disease and the fungus which occurs on diseased trees are exactly the same as in the previous description. Specimens of the fungus sent to Kew have been identified as *Polyporus Shoreæ* Wakefield—a species new to science—and the description published in the Kew Bulletin. The fungus is said to be readily distinguished from other species by the hard but brittle texture of the pileus, especially of the pores, when dry and the wrinkled deeply cracked dark crust. In living specimens the soft swollen whitish margin of the pileus is a distinctive feature. The basidia are normal and each bears fine hyaline spores from 2·5—3·5μ in diameter.

In culture the fungus grows well on a variety of media. On glucose agar the mycelium is largely submerged and produces a dense brown pigment; the hyphæ very often [illegible]. On sterile corn meal the fungus [illegible] produces structures which suggest fructification, however they have not produced any basidia or spores. The excretion of a yellowish liquid is a feature common to these structures in culture and to the pileus in the field.

Inoculations were carried out in the jungle at Rajah-Bhatkhawa in September of last year but defects in the method of this preliminary experiment, combined with the dryness of the season at the time of making the infection, proved unfavourable, and no conclusive results have so far been obtained. The inoculations were repeated this June,

with modifications suggested by the previous experiment, and a further series of infections is about to be carried out at Dehra Dun in co-operation with the Forest Botanist; it is hoped that these will yield decisive results.

(9) Other diseases of interest. The "black-dot" disease of potatoes caused by *Vermicularia varians*, was reported from Ranchi during the year. It was previously known only in France, Australia and South Africa. The extent of the injury it can cause is not yet determined. Peach leaf curl was found in the same locality and is reported to be very prevalent around Peshawar. It is hoped to arrange for trials in its treatment during the coming year. A disease of shaftal (*Trifolium repens*), caused by *Polythrincium Trifolii* (new to India) was found near Peshawar. Diseases of barley were much in evidence in the Pusa crop last season, the chief parasites recorded being *Puccinia simplex* and *Ustilago nuda* (not previously seen in India), *Puccinia glumarum*, *Ustilago Hordei* and *Helminthosporium gramineum*. A case of serious injury to a mango orchard at Malda from the fumes of a brick-kiln was examined. It differed from previous cases of the kind in the injury being chiefly to the fruit, not the branches. It is evident that the mango is peculiarly susceptible to such fumes. The study of the smuts of jowar, which are amongst the most destructive diseases in India, has been taken up by Mr. Kulkarni, Mycological Assistant to the Bombay Department of Agriculture, who completed his investigation at Pusa. No less than four distinct species attack this crop but the two more usual forms can readily be prevented by seed treatment. It is hoped to secure the universal adoption of this treatment ultimately, with a saving to the cultivators of several crores of rupees annually.

IV. Miscellaneous.

During my absence on leave the manuscript of a book on fungi as a cause of plant disease in India was almost completed. It has since been finished and revised and the

preparation of illustrations is now in hand. While engaged at Kew on this work an opportunity was taken of checking the nomenclature and determining the identity of many of the fungi that are responsible for crop diseases in India, by comparison with type material from the Herbarium of the Royal Botanic Gardens. I have to acknowledge the generous facilities given me by the Authorities at Kew and invaluable assistance from the Herbarium staff, especially Miss Wakefield and Messrs. Massee and Cotton.

As a result of the International Phytopathological Conference held at Rome early in 1914, the possibilities of legislation for the control of the spread of plant diseases have been recently much discussed. With the permission of the Secretary of State, I prepared a note for the Royal Horticultural Society on the dissemination of parasitic fungi as a basis for international legislation. This has since been written up with special reference to Indian problems and submitted for publication as a memoir of the Agricultural Department. At the Rome Conference a draft International Convention was signed by the delegates of some 30 States, and India will probably have to decide whether to adhere to this Convention or not, in the near future. Much consideration has been given to this question during the past year so that we may be in a position to advise when called on to do so.

V. Systematic Work.

The fifth part of "Fungi Indiæ Orientalis," based on material sent to Germany before the war, was published during the year. It includes a first instalment of determinations of the Pusa Herbarium collections of *Deuteromycetes*, comprising the *Sphaerioideæ* (173 species), *Nectrioideæ* (7 species), *Excipulaceæ* (4 species), *Leptostromataceæ* (3 species) and *Melanconiaceæ* (8 species). Seven new genera and 97 new species are described, the large proportion (nearly 50 per cent.) of new forms being due, no doubt, to the relatively little attention previously devoted to this group in the East. Many of them are crop parasites but

they are not, on the whole, responsible for as much damage as the mildews, rusts and smuts. The number of mounted sheets added to the herbarium during the year was 258.

VI. Programme of work for 1916-17.

(1) *Research work.* New fungus diseases of crops will be investigated as occasion arises but the following diseases will receive special attention and will constitute main lines of investigation.

(1) Ufra of paddy
(2) "Tokra" of tobacco and mustard
(3) Sclerotial disease and smut of sugarcane
(4) Wilt diseases of cotton, sesamum, gram and chilli
(5) Root rot of sál tree.

As minor investigations it is hoped to continue work on the anthracnoses of some field crops (especially chilli) and fruits.

(2) *Systematic work.* This will probably be in abeyance for the present, owing to difficulties in obtaining assistance from abroad on account of the war.

(3) *Training.* This will be continued on the same lines as in previous years.

(4) *Routine work.* Advice and assistance will be given as usual to Provincial Departments of Agriculture, the Forest Department, Planters' Associations and the general public.

VII. Publications.

(1) Shaw, F. J. F. & S. L. Ajrekar. The genus Rhizoctonia in India. *Mem. Dept. of Agri., India, Bot. Ser.* VII, No. 4, August, 1915.

(2) Shaw, F. J. F. . Report on Mycology, 1914-15, for the Board of Scientific Advice.

(3) Dastur, J. F. . A Rot of Bananas. *Agr. Jour. of India,* Vol. X, Part 3, July, 1915.

(4) Dastur, J. F. . Spraying for Ripe-rot of the Plantain Fruit. *Agr. Jour. of India,* Vol. XI, Part 2, April, 1916.

(5) Dastur, J. F. . Black Thread disease of Hevea in Burma. *Bull. 14, Department of Agriculture, Burma*, 1916.

(6) Sydow, H. & P. & E. J. Butler. Fungi Indiæ Orientalis. *Annales Mycologici*, XIV, Nos. 3 and 4, 1916.

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REPORT OF THE IMPERIAL MYCOLOGIST.

(E. J. Butler, M.B., F.L.S.)

I. Charge and Establishment.

I held charge of the Section throughout the year, and Dr. F. J. F. Shaw, D.Sc., A.R.C.S., F.L.S., remained as Second Imperial Mycologist. Dr. Shaw was absent on a course of musketry instruction at Pachmarhi, under the Indian Defence Force Act, during April, 1917. Babu N. N. Mukerji was appointed second clerk in place of Babu N. C. Sen, from August 2nd. Mr. S. N. Mitra, Second Assistant, and Babu P. C. Kar, Fieldman, returned from service under the Military Department in Mesopotamia on November 16th and their work in the campaign against flies was well reported on by their superior officers. Dr. Shaw received the degree of D.Sc., for research in Botany, from the London University during the year and Mr. J. F. Dastur, First Assistant, that of M.Sc., with distinction, in Botany, from the Bombay University.

II. Training.

Mr. Deoki Nandan, B.A., M.R.A.C., attended the Section as a private student up to the end of September. Mr. S. C. Bose, Assistant to the Mycologist, Indian Tea Association, was given a special course in laboratory technique from April 16th to May 16th. Lala Kripa Ram, L.Ag., Assistant to the Economic Botanist, Punjab, has been undergoing a special course of training since April 18th, 1917. Mr. G. S. Cheema, M.Sc., Research Scholar of the Punjab University, was permitted by the University to commence research work on plant diseases in the Mycological Section at Pusa during the vacation. He remained from June 1st to 27th, 1917.

III. Mycological Conference.

A combined conference of Mycologists and Entomologists was held at Pusa in February. There were joint

meetings on the 5th, when the proceedings were opened by the Agricultural Adviser, and on the 9th, to discuss the Rome Phytopathological Convention of 1914; on the other days the Mycologists met separately, and the sittings terminated on the 10th. Practically all those interested in Economic Mycology in India attended and much useful work was got through. This was the first occasion on which an attempt was made to bring together all the workers in the science in this country; the response and interest taken in the proceedings were most gratifying; and it is hoped to arrange similar meetings at periodical intervals, as part of a larger scheme for sectional meetings to be discussed at the next meeting of the Board of Agriculture. A report of the proceedings is in the press.

IV. Diseases of Plants.

The investigation and the demonstration of methods of control of plant diseases formed, as usual, the major part of the work of the Section. Crop parasites were collected and identified and advice given to the officers of the Department and the general public as occasion required.

(1) Paddy diseases. The investigation of *ufra*, a disease caused by an eelworm, *Tylenchus angustus*, Butl., was continued, in collaboration with the officers of the Bengal Department of Agriculture. During the past year, it has been traced across the Meghna into the districts of Backerganj and Faridpur, extending westwards as far as the river Madhumati. The area now known to be infected is, from east to west, from the Mahari river, near the Chittagong border of Noakhali, to the Backerganj-Khulna boundary, and, from south to north, from near Noakhali town, to the Dacca-Mymensingh boundary. Extension into Mymensingh, Khulna and Sylhet is probably going on. The Collector of Dacca reported that part of the winter rice crop was so severely damaged on the eastern side of the Madhupur Jungle and near the Lakhya river that it was not worth harvesting.

Experiments carried on at Pusa have thrown light on several of the anomalies in the parasitism of the eelworm which causes *ufra*. It was previously known that the spring crop, called *boro* rice, and also the transplanted autumn and winter rice, ordinarily escape the disease under natural conditions, though they can be readily inoculated artificially. As the *boro* fields are often surrounded by severely infected fields of winter (*aman*) rice, they are certainly frequently contaminated by diseased stubble from the latter, and it was not easy to understand why they are not attacked. It has now been conclusively proved that the worm cannot migrate so as to reach the upper parts of the rice plant, where alone it can feed, in dry air, but does so readily when the humidity of the air approaches saturation point, even though there is no film of free water on the plants. It has also been found that worms preserved dry retain their vitality and are able to renew active motion after at least eight months, while those kept in moist air remain alive for about four months, and those immersed in water for only one to two months. The *boro* fields are submerged in water from the time the crop is transplanted into them in December-January, until near harvest. Worms set free into this water from previously infected stubble, will die unless they can migrate from the water within a couple of months. While the seedlings are small, no doubt some can migrate to them at or near the water level, but the injury caused to rice plants at this stage of growth is slight. As the plants get bigger, only certain parts near the top of the shoot (above the upper joints of the stem and the young ear chiefly) remain susceptible to attack, as only these parts have unthickened cell walls. But the worm is unable to reach them, owing to the low air humidity between February and April, and so the plants escape the serious damage that results from an attack on the shoot while the ears are developing. The crop is harvested in April, before the humidity rises enough to allow any worms that may still remain alive on the lower parts of the plants to migrate to the top of the shoot. It has also been found that the worm

does not reproduce if immersed in water or if kept dry, but only in moist air. There is therefore no multiplication of the parasite in the flooded fields nor amongst any that may get carried up on the growing *boro* plants. If the plants are covered with bell jars, so that the air around them is kept nearly saturated, infection can readily be obtained from artificial inoculations at any time of the year. If not covered, successful infections can only be got during the rains and early cold weather, while the natural humidity is high.

The escape of the transplanted paddy is due to the fact that it is grown on relatively high ground. The crop is harvested so that not much stubble is left, and the fields are ploughed early. It has been proved that worms set free into the soil do not remain alive long, and the new crop is not transplanted out until much after the period that has proved sufficient to free the soil from infection. If worms could reach the transplanted fields from neighbouring infected broadcasted fields, they would doubtless attack the transplanted paddy; but as a rule the flood water does not rise sufficiently to establish direct connection until relatively late in the season, and often not at all. That infection in this way does, however, sometimes occur is probable from the occasional reports that have been received of injury to the transplanted winter crop.

In certain parts of the infected area, the rice *bhils** are narrow and deeply concave. In the bottom of these, the soil remains muddy until February and, where deep-water *aman* has been grown, a second growth of small shoots and ears, arising from the long, matted stubble, can be found up to mid-February. In infected *bhils* this second growth harbours large numbers of actively feeding and multiplying worms. The ground does not dry out sufficiently to permit of ploughing until February in many cases, and the new crop has to be broadcasted very soon—in March—as the *bhil* bottoms flood early. Hence the worms have only about a month to live through before the new crop is sown and free

*Basin-like depressions which always hold water in the rains.

water collects, and about another two months before the humidity rises (in May) enough to permit of migration. Reports are common that the earliest attacks of *ufra* are seen in these low lying patches, which is just what would be expected. It is not suggested that *ufra* always, or even frequently, arises from these low-lying patches, as it has been conclusively proved that the stubble in the paddy flats that dry out in December, as the great bulk of them do, is equally able to carry over infection to the next crop. But whereas it is relatively easy to remove the infected stubble and plough early in the latter, this cannot readily be done in the former. So long as the soil remains muddy, it is practically impossible to allow the work-cattle into it, and even if the stubble could be collected, it is too wet to burn properly in December. When the stubble can be removed and the land ploughed, it is so near sowing time that the chances of killing out the worm before the new crop appears are scanty. There appear to be only two ways of dealing with these muddy patches : to drain them so that they dry in time to permit of effective stubble destruction; or to deepen them so that they can grow *boro* paddy. The latter is only possible in the vicinity of permanent waterways or *khals*, as the *boro* crop has to be irrigated during its growth, but as these *khals* replace roads throughout much of the area, there is a general demand for new ones wherever practicable. - Experiments have been started to ascertain the best way of dealing with this problem.

An attempt to induce the paddy cultivators to burn the stubble and plough early was made. Leaflets were distributed throughout the infected area and several demonstrations were arranged for, partly by the Department of Agriculture and partly by the revenue officials. In the Sadar Sub division of Tippera, 12 previously diseased plots were treated, all of which escaped *ufra;* in Chandpur 64, of which 9 got slight attacks. There was less *ufra*, however, in this district than for several years. In Dacca the land selected was very swampy and the treatment was ineffective, probably for the reasons given in the last paragraph.

When the rice worm was first described (*Pusa Bulletin* No. 34, 1913) no other instance was known of injury to cultivated plants caused by an eelworm with the peculiar surface-feeding habits of *Tylenchus angustus*. Quite recently, however, a second case has been recorded, on currants, near Cambridge (England). It seems probable that others will be discovered, now that attention has been directed to the economic importance of this type of nematodes. An account of the present stage of the investigation is in preparation for publication.

(2) **"Tokra" of tobacco and mustard.** Further experiments were carried out by Dr. Shaw with the object of testing the claim that sodium nitrate was a specific against this pest. The results of the previous season's work had been partly obscured by the fact that the amount of "tokra" appearing in a plot seemed to depend as much upon the degree of infection in the soil as upon the influence of any application of sodium nitrate. During the season 1916-17, the experimental plots were so arranged, in the light of the information gained during the previous season, that this factor was eliminated. It was then found that the amount of "tokra" which came up in any particular plot depended largely upon the degree of infection in the soil and was practically uninfluenced by any application of sodium nitrate upon an agricultural scale.

The species of *Orobanche* examined were *O. cernua* Loefl. and *O. indica* Ham. and, as in the previous season, the former proved to be restricted to *Solanaceæ* while the latter occurred principally upon *Cruciferæ* and only to a modified extent upon *Solanaceæ*. With a view to testing the parasitism of these species in greater detail than was possible within the limits of a field experiment, a series of pot cultures was carried out. Four host plants were used, namely tobacco, cabbage, mustard and turnip, and these host plants were infected with seed of *O. cernua* and *O. indica* which had been collected from "tokras" parasitic both upon the species of host plant infected and upon the other three host plants. Thus pots containing tobacco

plants were infected with seed of *O. cernua* collected from *O. cernua* upon tobacco and with seed of *O. indica* collected from *O. indica* upon mustard, from *O. indica* upon tobacco, from *O. indica* upon cabbage and from *O. indica* upon turnip. The same treatment was applied to mustard and to the other host plants. The results showed that *O. cernua* was strongly parasitic upon tobacco and did not attack the other three hosts, while *O. indica* was not parasitic upon tobacco unless the seed used had been collected from plants which were parasitic upon this host, in which case such seed was not capable of infecting mustard plants with "tokra." Seed of *O. indica* collected from plants parasitic upon either mustard, cabbage or turnip, however, would not infect tobacco but was strongly parasitic upon all of these hosts. Thus there appear to be two races or strains of *O. indica*, one parasitic upon tobacco and not infecting mustard and the other parasitic upon mustard, or the allied cabbage and turnip, and not infecting tobacco. Certain of the pot cultures received heavy applications of sodium nitrate, which, however, did not have any marked effect upon the occurrence of the tokras; the details and results of all the above experiments are now in the press.

(3) **Phytophthora investigations.** Mr. Dastur has continued his studies on this important genus. The Black Thread disease of Para rubber trees is fully described in the Memoirs and, as a result, the attention of other workers has been directed to the similar condition prevalent in Ceylon and Java. It seems clear that the disease is found in most parts of the East where rubber is grown, but the Java workers still hold that it is due to the same parasite that causes the well-known rubber canker, and is not a new disease. Mr. Dastur has given reasons for believing the parasite to be a distinct species, a matter of considerable economic importance since the canker fungus is common especially in the neighbourhood of infected cacao trees. He has found the Black Thread fungus to be much more restricted in its parasitism than *Phytophthora Faberi*, the canker fungus, and has quite failed to get it to attack cacao and other hosts

of the latter. The remedial measures recommended are being tested on a plantation scale in Burma. The chief are the free admission of light and air amongst the trees by judicious thinning, and the cessation of tapping during the monsoon months on all diseased trees. In South India, where the same or at least a closely allied disease is under investigation, good results have been obtained by the application of antiseptic and waterproof smears to the cut surface left after tapping. Tar and tallow; sulphur, cowdung and clay, have been used, and no doubt other more efficient mixtures will be found. It is not yet certain whether similar measures will be required in the relatively drier parts of the Burma rubber districts and, at the time of writing, Mr. Dastur is carrying out further enquiries in Burma.

A second Memoir contains an account of a biologic variety of *Phytophthora parasitica*, Dastur, found in Pusa on *Vinca*. It is a weak parasite, inoculations failing as a rule unless the atmosphere is almost saturated with moisture, but succeeding in damp air on a considerable number of garden plants. The fungus is, therefore, of more scientific than economic interest.

In a third paper, Mr. Dastur discusses the conditions influencing the distribution of *Phytophthora infestans*, the cause of the common potato blight. In India the fungus is ordinarily restricted to the Himalaya, Khasi and possibly Nilgiri Hills, but periodical outbreaks have been observed in the Gangetic plain and the valleys of Assam and Sylhet. An analysis of the conditions leading to these attacks, indicates that temperature, moisture and source of origin of the tubers are all important factors in controlling the distribution of the disease. Long exposure to temperatures above 77°F., is already known to be fatal to the fungus and such temperatures are usually found at the time of sowing the plains' crop. Furthermore, damp weather at the period of fructification of the fungus (January and February in the plains) is necessary to permit free reproduction and dissemination. And unless the tubers come from some already infected area, such as the Himalaya or Khasi Hills,

they are not liable to contamination and they will escape disease in the plains, since the plains' crop is normally free and local infection not usually to be feared. The outbreaks investigated showed that the seed used was probably infected, that it was brought from the Hills when the temperature below was under the normal for sowing time, and that the crop was exposed to rain or ground fogs as it ripened. Unless all these conditions are met, the crop may be expected to escape in the plains and in most of peninsular India.

(4) Rhizoctonia and other sclerotial diseases. A severe attack of *Rhizoctonia* on jute in the experimental plots on the Dacca Farm enabled the interesting observation to be made, in July, 1916, that plots which had received heavy fertilization were practically immune. As the experiment did not give any indication of the constituents which led to this result, a new series was laid down by Mr. Finlow, Fibre Expert to the Bengal Government, and in a recent report this officer states that the results strongly suggest that potash deficiency is the main cause of the severity of the disease on the old alluvium north of Dacca. The enquiry is being followed up in connection with the accumulating evidence that certain Indian soils are dangerously deficient in one or other of the essential constituents of plant-food, and that this deficiency may be manifested in increased susceptibility of the crop to fungus diseases. This point will be further referred to under " tikka " disease of groundnut.

From time to time reports and specimens of a serious root rot of cotton in northern and western India have been received. A local investigation in the southern Punjab, supplemented by a re-examination of the material in the Pusa collections, revealed a certain definite train of symptoms, enabling the disease to be recognized with certainty. Its cause is very obscure, several fungi being present on the roots of most specimens, but none so extensively nor so regularly as to be the probable cause. Two have been isolated for further work, a *Rhizoctonia* and a sterile, non

sclerotial form. Inoculations with the former, which is present on almost all diseased plants, but often apparently in very small quantity, were carried out at Pusa but under somewhat unsatisfactory conditions as the season was far advanced and the available plants old. They gave negative results. Further trials will be made with this and the second fungus. During the enquiry, we were again confronted with the probability that there was some condition connected with the chemical composition of the soil in which this root-rot occurred which was the predisposing factor. This condition may be a weak concentration of harmful alkali salts, but the evidence is contradictory in some aspects and further enquiry and experiment will be required.

Sclerotial diseases of sugarcane and paddy. Dr. Shaw continued his investigations on these diseases throughout the year in the laboratory at Pusa and during a tour to Sindewahi Farm, Central Provinces. The specimens originally received from the Central Provinces ultimately yielded two sclerotial fungi in culture. One of these was *Rhizoctonia destruens*, Tass. and the other has not at present been identified. This second form possesses a mycelium which is almost indistinguishable from that of *R. destruens* but its sclerotia are large, irregular, white bodies very different from those of *R. destruens;* both these fungi proved to be parasitic upon the leaves of sugarcane. At Sindewahi, however, it was obvious that the most serious parasite was the second, unidentified, sclerotial fungus. This occurred all over the farm on scattered clumps of cane and resulted in the complete death of the outer leaves. The early stages of attack appeared as red spots on the leaf sheath, the inner side of the leaf sheath being covered with a thick sugary solution containing a fungal growth. As the spot spreads the mycelium forms a thick crust on the interior of the leaf sheath and the sugary solution dries up. Finally the leaf is left as a dry and withered scale and sclerotia are produced along its edges. Cultures were obtained at Sindewahi from the mycelium on the leaf, from sclerotia on the leaf, and from sclerotia in the soil. In

every case the same organism was produced in culture and inoculations with these cultures have been successful in producing the disease upon canes at Pusa. The hyphae appear to enter the leaf through the stomata and penetrate the tissues of the leaf in all directions; microscopic work on this subject is proceeding. The disease appears to be very similar to that known in Java under the name of " Het zuur Rot."

Specimens of a different sclerotial disease of sugarcane were received from Eastern Bengal during the year and appeared to be identical with the disease which is known in Java as " Djamoer Oepas." In this case very characteristic light brown spots with a dark margin occurred on the blade of the leaf together with a fungus having a brownish mycelium and irregular brown sclerotia. Both the parasitic organism and the resulting spots on the leaf were very similar to the sclerotial fungus and the leaf spots described below upon paddy.

The fungus *Sclerotium Oryzæ* Catt. was very prevalent upon specimens of diseased paddy from the Central Provinces, and associated with *S. Oryzæ* on these specimens a second sclerotial fungus was found. This latter form possessed small brown spherical sclerotia, very regular in shape and size. The fungus was obtained in culture and its parasitism upon paddy is being investigated.

Paddy in Pusa sometimes suffers from the attack of another species of sclerotial fungus with large, brown, irregular sclerotia and hyphae of the *Rhizoctonia* type. This fungus causes very distinctive spots upon the leaf sheath; these spots when mature have a light brownish central area surrounded by a dark red brown line, the central portion consists of dried and dead leaf tissue and the darker margin probably represents the active zone of the fungus. The external symptoms resemble very strongly those of the sclerotial disease of sugarcane from Dacca, and it is possible that the causal organism in the two cases is the same, but the present fungus on paddy has several points of agreement with the species *Sclerotium irregulare*, described by

Miyake as parasitic on leaf sheaths of paddy in Japan. This fungus has been obtained in culture and successful inoculations in Pusa have succeeded in producing the typical leaf spots. Further research is in progress to determine the method of parasitism and the extent of damage resulting to crops.

Several other sclerotial diseases of minor importance were observed during the year, among which the most serious were an attack of *Rhizoctonia destruens*, Tass. upon wheat and lentil (*Lens esculenta*) in Burma, and a collar rot of lemon seedlings at Nagpur caused by an unidentified species of this genus, which is also parasitic upon chilli and *Hibiscus* in Pusa. All of these fungi have been obtained in pure culture and are being studied.

(5) Anthracnose of chilli and pulses. The serious disease of chillies in Bihar, referred to *Colletotrichum nigrum* E. and Hals. in last year's report, has been found to be due to an allied but distinct fungus *Vermicularia Capsici*, Syd. The former is a North American fungus and was found to be different from the Bihar species on comparison by the mycologists of the United States Department of Agriculture, who have, as usual, given us every assistance. Subsequently the true *Colletotrichum nigrum* was found in Burmese specimens, while a third form, *Glomerella* (*Gloeosporium*) *piperata*, S. & v. S. occurs sporadically throughout India. It appears to be better to restrict the term anthracnose to these two last-named (possibly only different forms of the same fungus) and to call the disease caused by *Vermicularia* " die-back," from its most prominent symptom, the withering back of the top shoots of the plant. Mr. Dastur has carried out a more detailed study of " die-back," which it is hoped to publish during the coming year. Meanwhile experiments in its treatment are in progress. The results anticipated from the seed selection referred to in last year's report have not materialised : disease was almost as severe in the plot grown from selected as in that from non-selected seed and it is evident that the fungus does not rely on seed-infection to

secure its perpetuation. Fortunately it seems that control by spraying will be relatively easy and a detailed series of experiments has been laid down to test spraying during the present season.

The same *Vermicularia* has been found to be one of the causes of a disease of various pulses, such as cowpea and Dolichos, and of Solanaceous plants, such as tomato and brinjal. As in chillies, it has been previously confused with the anthracnoses of these crops, but it seems to be of relatively minor importance on these hosts. It has not yet been recorded outside India, except in the Philippines.

(6) "Tikka" disease of groundnut. An outbreak of this disease on the Ranchi Farm was investigated. The soil of this farm is singular in being almost devoid of sulphur, and is also markedly deficient in phosphorus. It appears from analyses carried out in Bombay that groundnuts require relatively large quantities of the latter constituent, and as the nuts mature there would seem to be a heavy drain on the phosphates of the soil. It was observed by Mr. Dobbs, Deputy Director of Agriculture, Bihar and Orissa, that at this period the disease set in and developed with great intensity. Experiments have been arranged by Mr. Dobbs this season to test the view provisionally arrived at that "tikka" disease may be symptomatic of deficiency in available phosphates, in other words may be a deficiency disease similar to jute *Rhizoctonia* as described above.

(7) Sal tree disease. The investigation on the root rot of the sál tree was continued by Dr. Shaw during the year, efforts being principally directed towards completing the life history of the fungus in artificial culture and establishing its parasitism upon the sál by means of direct infections. With this latter object, a series of inoculations was carried out in June, 1916, at Rajabhatkhawa and in August, 1916, at Dehra Dun. The inoculations at Rajabhatkhawa were examined in December last and failed to yield conclusive results. In the case of one of the trees which had been infected with cultures of *Polyporus Shoreæ*, the disease was found to be well established, but it was obvious that this

was the result of a natural infection from two neighbouring trees which had since died. In fact it is most probable that this tree was already infected in the lower roots when the inoculations were made in June, 1916, but that the disease had not at that time spread sufficiently near the surface of the soil to be visible or produced sufficiently marked external symptoms to enable the tree to be distinguished from its apparently healthy neighbours. This case serves to call attention to a great difficulty in the work at Rajabhatkhawa, namely, the impossibility of knowing whether a particular tree is or is not infected with the disease. The final stages of the disease are easily identified, the defoliation and death of the tree being accompanied by the production of a large fructification and the presence of " partridge wood " in the whole of the external tissues of stem and root in the region of the ground level. A little earlier than this however the tree appears quite healthy, and the diseased tissues can only be found at a point about 1 foot below the ground level, or perhaps diseased tissues may only be discovered by going down to a depth of 6—8 feet. It is therefore impossible to say that a tree is free from infection until the bulk of the roots have been laid bare, after which it is hardly a fair subject for inoculation experiments. This objection does not however apply to the infections carried out in collaboration with the Forest Botanist at Dehra Dun and it is hoped that these may yield more decisive results; arrangements have been made to examine them in September, 1917.

It is worth noting here that in diseases of large trees caused by Basidiomycetous fungi, the parasitism of the causal fungus has not invariably been established by the method of direct inoculation, the constant association of the fructification of the fungus with the symptoms of the disease and the presence of the mycelium in the tissues being, in some cases, the only direct evidence of the parasitism of a particular species. From this point of view some interesting information and figures should in a few years be obtainable from the " fungus observation areas " in the

Buxa Division. Even now, after only two years' continuous observation, it appears that the fungus is spreading rapidly and that the death rate of trees on which the fungus occurs is, in some plots, high : this rate however shows considerable variation from one plot to another. It must be remembered that in a slow growing forest crop such as sál, a low yearly percentage of loss, which in the case of an annual agricultural crop would be negligible, may be very serious.

(8) Peach leaf curl. This disease has long been the cause of serious loss in the important fruit-growing districts of North-West India and until recently was not considered susceptible of treatment by spraying, the relatively unsatisfactory methods of pruning and burning diseased branches being the only remedial measures advocated. Experiments conducted in America have however shown that the spread of this parasite—*Exoascus deformans*, (Berk.) Fuckel—by air-borne infection plays a very extensive part in the spread of the disease and that spraying with Burgundy mixture just before the buds open is an effective control against this trouble. In co-operation with the Agricultural Officer, North-West Frontier Province, an extensive trial of this method was carried out in the Government Orchards at Taru during January, 1917, with results which have proved very encouraging, there being a considerable difference between the sprayed orchard and neighbouring private orchards. Trials were made both with lime-sulphur mixture and Burgundy mixture and both proved satisfactory. Owing however to the ease with which it can be prepared, the latter will be the most popular with the cultivator. Spraying is to be continued at the Government Orchards during future seasons and it is hoped to introduce the practice to fruit-growers in the district and to lessen materially the damage done by this destructive disease.

(9) Other diseases of interest. The powdery scab of potatoes caused by *Spongospora subterranea*, (Wall.) John., was received from Bombay Presidency. This is the first record of any parasitic member of the Myxomycete family

in India and the first time any potato scabbing organism—common though they are in the West—has been found in this country. A considerable amount of time was given to the identification of tea and coffee parasites sent in by the officers of the Planters' Associations concerned or personally collected in previous years. In tea, Mr. Tunstall, Mycologist to the Indian Tea Association, has taken up the study of the numerous root diseases, and amongst the material he sent in was found *Sphærostilbe repens*, B. and Br., now first recorded as a tea parasite, and *Rosellinia bothrina*, (B. and Br.) Sacc. not previously known in India but found on tea in Ceylon. In coffee it was found that the Java "spider's web" disease and the widely distributed brown eye-spot disease (*Cercospora coffeicola* B. and Cke.) both occur in India, but are apparently uncommon. The suspected parasite *Pythium gracile*, Schenk, occurred on young tobacco, and Babu L. S. Subramanium was able to get it into culture, thus allowing of an accurate examination of its parasitic tendencies. So far it has been proved to attack ginger rhizomes readily, causing the soft rot disease which was described in the *Agricultural Journal of India* (Vol. VI, 1911, p. 139), as prevalent in Rangpur and Surat. It is also parasitic on tobacco and probably other crops. It is hoped to publish an account of this work shortly. Experiments with the smut of *bajra* (*Pennisetum typhoideum*) established that this disease is not influenced by rotation of fields, thereby suggesting that it is seed-borne. Attempts at seed disinfection have, however, failed. An apparently new disease of paddy due to the attack of a species of *Cephalosporium* or *Verticillium* was received from Lyallpur. The fungus is being studied and inoculations have been tried. The damage at Lyallpur was estimated at 15 per cent. of the crop and it is possible that a new and serious parasite of paddy has been discovered.

V. Miscellaneous.

The problems connected with international legislation against plant diseases, continued to engage attention. In

order to establish the scientific basis on which legislation must rest, an examination of the factors controlling the dissemination of parasitic fungi has been completed and published. Two types of dissemination should be distinguished: continuous or short-range, and discontinuous or long-range. For the former, fungi are so well equipped that measures to check it are likely to prove abortive: for the latter, on the other hand, a great body of evidence has been got together to show that, if we exclude human agency, fungi are not in a position to make such considerable jumps as to be able to cross the seas or spread from one part of the world to another at all readily. Most of the important plant diseases that have appeared in recent years can be traced to the movement by human agency of the living plant which they attack, from one part of the world to another; they follow trade routes; and when, one after another, the more isolated parts of the world are brought into contact with western civilization and opened up to trade and exploration, each lets loose its indigenous pests and diseases to infect the countries with which commercial relations become established. It is not realized how thoroughly new countries are searched for economic plants, nor how quickly attempts are made to introduce novelties, or even varieties of already cultivated kinds, from them. It is open to question whether the benefits gained from such sources are not more than counterbalanced by the new diseases that have thus been introduced.

The book on fungi causing crop diseases in India, referred to in last year's report, has been completed and is now in the press. It deals with the general principles of plant pathology and gives a detailed account, crop by crop, of the more important diseases of cryptogamic origin found in Indian field and plantation crops.

VI. Systematic Work.

This has been largely in abeyance during the year, partly owing to the difficulty of obtaining foreign assistance under present conditions. Several collections have been identified

for officers of the Agricultural and Education Departments and for others interested in Mycology. Several pathogenic species of *Aspergillus* have been sent in from the Institute of Analyses and Vaccines at Nova Goa (Portuguese India), and the interesting discovery was made that the fungus habitually found in heart-damaged bales of jute is *Aspergillus fumigatus*, Fres., already known to occur in Indian soils and to be, in other countries, a not uncommon cause of ear and lung disease in man. The new additions to the Herbarium amounted to 450 sheets.

VII. Programme of work for 1917-18.

(1) *Research work.* New diseases of Indian crops that come to the notice of the Section will be investigated as opportunity permits, but the following diseases will receive special attention and will constitute main lines of investigation.

(*a*) " Ufra " of paddy.
(*b*) *Orobanche* of tobacco and mustard.
(*c*) " Die back " and anthracnose of chilli.
(*d*) Sclerotial disease of sugarcane and paddy.
(*e*) Root rot of sál tree.
(*f*) Wilt diseases of cotton, sesamum and gram.

Minor investigations will include the study of some fruit anthracnoses, of the soft rot of ginger and of the root rot of cotton.

It is hoped to publish a hand book of diseases of crops.

(2) *Systematic work.* This will be in abeyance for the present owing to difficulties in obtaining assistance from abroad on account of the war.

(3) *Training.* This will be continued on the lines indicated in the prospectus. Short courses may also be given as necessary.

(4) *Routine work.* Advice and assistance will be given as usual to Provincial Departments of Agriculture, the Forest Department, Planters' Associations and the general public.

VIII. Publications.

(1) Butler, E. J. . Report on Mycology, 1915-16, for the Board of Scientific Advice.

(2) Dastur, J. F. . *Phytophthora* sp. on *Hevea brasiliensis*. *Mem. Dept. of Agri., India, Bot. Ser.*, Vol. VIII, No. 5.

(3) Dastur, J. F. . *Phytophthora* on *Vinca rosea*. *Mem. Dept. of Agri., India, Bot. Ser.*, Vol. VIII, No. 6.

(4) Butler, E. J. . The Dissemination of Parasitic Fungi and International Legislation. *Mem. Dept. of Agri., India, Bot. Ser.*, Vol. IX, No. 1, February, 1917.

(5) Dastur, J. F. . Conditions influencing the distribution of Potato Blight in India. *Agri. Jour. of India*, Special Science Congress Number, 1917.

(6) Shaw, F. J. F. . *Orobanche* as a parasite in Bihar. *Mem. Dept. of Agri., India, Bot. Ser.*, Vol. IX, No. 3. 1917.

Proceedings of the Mycological Conference held in February, 1917.

REPORT OF THE IMPERIAL MYCOLOGIST.

(E. J. Butler, M.B., F.L.S.)

I. Charge and Establishment.

I held charge of the Section until 8th July, when I proceeded to the Federated Malay States on deputation to advise on some matters connected with the local Agricultural Department. Dr. Shaw, Second Imperial Mycologist, officiated for me until my return to India on 14th November. During this period Mr. Dastur, First Assistant, officiated as Second Imperial Mycologist.

I was appointed Joint Director of the Agricultural Research Institute, Pusa, in addition to my own duties, with effect from 20th January. Mr. Dastur was promoted to the Imperial Service and appointed Supernumerary Mycologist on 30th June, 1919.

II. Training.

Mr. M. Mitra, M.Sc., did a short period of research work, as a private student, up to 28th August, 1918, and again joined for a complete course on 27th May, 1919. Pandit S. D. Joshi, B.Sc., a private student, is taking the full course from 12th June, 1919.

III. Mycological Conference.

The second conference of mycological workers in India was held last February, and was constituted, under the orders of the Government of India, as a sectional meeting of the Board of Agriculture. Under these orders, which were issued as a result of the discussions at the Board of Agriculture meeting at Poona in 1917, it is intended to hold similar meetings biennially in those years in which the biennial meetings of the full Board do not take place. The meeting was attended by practically all the mycologists in India and lasted four days. A separate report of the proceedings has been issued.

IV. Diseases of plants.

(1) Ufra of rice. An account of the investigations on this disease carried out since the Bulletin published in 1913 was issued as a Memoir early in 1919. This contains a further study of the life-history and activities of the rice worm, *Tylenchus angustus*; an attempt to explain the anomalies in the behaviour of different classes of cultivated paddies to the disease, which were noticed in the earlier paper but which remained a complete puzzle until the close relation between atmospheric humidity and the movements of the worm on a dry surface was discovered; and finally the application of the facts ascertained to the control of the disease. Further work is in progress or contemplated regarding the factors which influence the motility of the worm and those which influence its persistence under field conditions from one season to the next.

(2) Black Band disease of jute. The research work on this disease was continued by Dr. Shaw during the year under review. The amount of disease in the Bihar jute crop was considerably less in 1918 than in the previous year. This was very possibly due to the earlier termination of the monsoon, and the consequent exceptional dryness during September, resulting in the jute seed crop being harvested a month earlier than in 1917. On the Pusa Farm, while the incidence of the disease was slight in the main area of the crop, one small field was very badly infected. This particular area had been under jute in 1916. Whether the intensity of the disease in a crop is in any way bound up with the length of rotation practised is a factor which must be considered in future field experiments. The fact, mentioned in the last report, that the late sown crop appears to be relatively immune was abundantly confirmed from the inspection of the jute crop all over Bihar. Statistics obtained from the diseased portion of the crop on Pusa Farm showed that it is only stems of a certain size and maturity which are liable to infection under natural conditions in the field. Thus of stems over 5 feet high about 20-25 per cent. were infected with *Diplodia*

Corchori, and the same proportion of diseased plants was observed on counting only stems which were 1 inch or more in thickness at the ground level. In any jute crop, however, there is a considerable number of plants which are the result of late germination and in which the stems remain thin and relatively short. Among stems of this size the disease was practically non-existent, and if such plants are included in the estimation the proportion of diseased stems may be as low as 3 per cent. The proportion of diseased stems among the larger plants, however, gives a more accurate measure of the extent of damage to the crop.

In Eastern Bengal, in August and September, 1918, the fungus was found present in Dacca, Mymensingh, Sinjhani and Haldibari. The number of diseased stems was very small, however, and unless the disease appears earlier it is evidently not likely to be a serious source of damage to the fibre crop. An interesting fact observed was that, in Dacca, red-stemmed varieties of *Corchorus capsularis* seemed to be less susceptible to attack than green-stemmed. On the Rajshahi Farm the crop was *C. olitorius*, both red and green-stemmed varieties, and in this crop also the disease was practically absent. Inoculations now in progress do not, however, support the idea that red-stemmed forms are absolutely immune. A number of artificial infections on the variety "kakya bombai" were carried out in the field, and of inoculations upon wounded stems 90 per cent. proved fatal and upon uninjured stems 50-60 per cent. resulted in the death of the plant. The success or failure of an infection upon an uninjured stem is probably very closely related to the conditions of temperature and humidity at the time and an endeavour will be made to elucidate the relative importance of these factors in the success of an inoculation. Microscopic examination shows that the hyphæ are capable of penetrating the epidermis directly and set up a rapid rot and disintegration in the cortex. This suggests the presence of a cytolytic enzyme, and indeed the fungus has been cultivated successfully on pure cellulose in a solution of inorganic salts.

During the season 1918 a series of field experiments was carried out with the object of throwing some light on the condition affecting the spread of the disease. The results were not so definite as was hoped, the experiments suffering considerably from the abnormal monsoon of 1918, but suggested that the spread of the disease through spores mingled with the seed was not an important means of dissemination. In this case it may not be necessary to persist in the steeping of the Bihar seed crop in a disinfectant. As a precautionary measure, however, the treatment with copper sulphate was carried out this year with some 40 tons of seed grown in Bihar.

While working on the black band disease of jute, a number of cases of disease due to infection with the sclerotial fungus previously identified as *Rhizoctonia Solani* Kühn were met with. It is by no means uncommon in the field for both this fungus and *D. Corchori* Syd. to occur on the same plant, and at first the natural tendency was to assume that all the pycnidia which were so frequently found associated with the sclerotial fungus were immature pycnidia of *D. Corchori*. In 1917 some jute plants were infected with pure cultures of *R. Solani* and all the plants became diseased and died. Upon the diseased portion of the stem small black pycnidia appeared. As these infections were carried out on plants in a field in which *D. Corchori* was rampant, it was thought that we had here a case of a natural infection with *D. Corchori* superimposed upon the artificial inoculation; a brief microscopic examination showing a condition which was considered to be immature *D. Corchori*. In 1918 observations at Dacca showed some cases of disease due to *R. Solani* in which the infection had obviously commenced at a point 2-3 feet above the ground level, and at the time it was by no means plain how a fungus which was only known in a sclerotial form succeeded in establishing itself in this way. Moreover, these specimens and other similar cases in the Pusa crop also showed a pycnidium on the outer surface. These pycnidia and those occurring on the infections of 1917

were now subjected to a more critical examination. The field specimens from Dacca and Pusa both agreed with the infected stems of 1917 in the character of the pycnidium and spores which it contained. While this resembled an immature stage of *D. Corchori* very closely it was obvious that, in the case of the 1917 infections, since they were at the time of this later examination nearly a year old, if the pycnidia were those of *D. Corchori* they should contain mature bicellular spores. In all cases, however, the spores were hyaline, oval and unicellular, and the possibility that this pycnidium was not an immature condition of *D. Corchori* but was a separate fungus, perhaps a stage in the life-history of the sclerotial fungus, had to be investigated. Measurements showed that the spores from the infected stem of 1917 were $16\mu-33\mu \times 5\mu-9\mu$. In the case of specimens collected in the field in Pusa the measurements were $16\mu-25\mu \times 7\mu-9\mu$, and in specimens from Dacca $20\mu-28\mu \times 7\mu-10\mu$. The spores of *Diplodia Corchori* average $24\mu \times 12\mu$, between the limits $20\mu-29\mu \times 10\mu-15\mu$; while therefore the spores of *D. Corchori* are twice as long as broad, those of the new pycnidium are about the same length but narrower. This distinction is not sufficiently marked to enable these spores to be readily distinguished from those of an immature pycnidium of *D. Corchori*, but since the former never become dark coloured or bicellular they can easily be distinguished, provided the age of the infection from which they are taken is known

The question whether this new pycnidium was a stage in the life-history of the sclerotial fungus, identified in previous communications as *R. Solani*, could only be settled by culture work. Since this work is in progress at the time of writing, it is possible that the conclusions put forward here may be modified in the light of subsequent knowledge. Infections were carried out with a pure culture of the sclerotial fungus, isolated in Dacca, on four jute plants in Pusa. All these plants developed sclerotia and also pycnidia, containing spores measuring $16-24\mu \times 7-9\mu$. Cultures were obtained on agar from single spores and from

single sclerotia, and in both cases produced the sclerotial fungus (*R. Solani*) exactly as the original inoculum. Diseased plants from Dacca were found to carry both *R. Solani* and a pycnidium containing spores $20-28\mu \times 7-10\mu$. Cultures from single spores and single sclerotia from these specimens both gave the sclerotial fungus. The suggestion, therefore, is that the pycnidium is a spore-bearing stage of the sclerotial fungus, and that this pycnidium only occurs on the jute plant, the sterile form occurring in culture.

In April, 1919, a reference was noticed, in a current mycological journal, to a fungus parasitic upon jute in Formosa. The fungus was named *Macrophoma Corchori* Sawada sp. nov., and from the description appeared to be identical with the pycnidium described above. By the courtesy of Professor Kaneyoshi Sawada material of this fungus has been obtained from Japan and examined in Pusa and found to agree with the Indian specimens. Specimens have been sent to Japan in order that a similar comparison may be made there.

(3) Fruit work in Kumaon. The root rot of apple and cherry trees due to a species of *Rosellinia* continued to cause a certain amount of loss. Some dead trees have been left standing in the hope that the perfect stage of the fungus will be produced and will enable the species to be identified. This disease was most severe on a section of the orchard which had been recently cleared of jungle and, as mentioned in the last report, is generally worst on the black soils which are rich in humus acids. It also appears to be favoured in situations where drainage is deficient, and extensive drains are projected on one orchard.

The apple cracking and branch blister, which was attributed to the fungus *Coniothecium chomatosporum*, was not so severe. Field observations have raised considerable doubts as to whether this disease in Kumaon is of the same nature as that described in Europe and South Africa under this name. Thus while the cracking of apples occurs on one variety, the branch blisters are present on two other varieties of which the fruit is undamaged. Further work

is necessary before the conclusions of previous authors can be entirely accepted. Spraying experiments with lime-sulphur, Berger's lime sulphur and Burgundy mixture failed to check completely the disease. About 5 per cent. of the fruit of a certain variety, on both sprayed and unsprayed trees, was damaged.

Apple mildew (*Podosphæra* sp.) is perhaps the most widespread of the fungal troubles of apple trees in Kumaon. This disease seems to spread rapidly during the month immediately preceding the break of the monsoon. Spraying with lime sulphur during this period was not very efficient in controlling the disease, although in one or two cases, in which, at the risk of damaging the tree, a heavy application of double "summer" strength lime sulphur was applied, the disease was brought under control and infected shoots produced a further growth of healthy leaves. During 1918 mildew was especially severe on one orchard on which during that year no spraying had been carried out. In 1919 the spraying upon this orchard was done with a mixture containing iron sulphide, prepared according to the formula recommended for the Pajaro Valley, and mildew was very much less than in the previous year. Experiments will be carried out during the coming season to test the relative merits of iron sulphide and lime sulphur as sprays against apple mildew. Of the various varieties of apple, "Northern Spy" is the most liable to mildew in Kumaon, and serves as a centre of infection for other varieties. It is being destroyed on one orchard.

Fly speck and sooty blotch (*Leptothyrium Pomi*) is a disease which, while not actually damaging the apple, affects the market value of the fruit owing to the unsightly markings which it causes on the skin. This disease was much less severe on the trees which had been sprayed with lime sulphur than on trees which had not been sprayed at all.

Peach leaf curl (*Exoascus deformans*) had been serious in 1918, and in 1919 certain areas under peach were treated with lime sulphur, Burgundy mixture and Berger's lime

sulphur. All these sprays proved efficacious and there was not a single case of the fungal leaf curl in the sprayed areas. It was very interesting to note that one tree which had escaped the attention of the spraying gang became covered with the leaf curl.

During the progress of the spraying experiments in Kumaon striking differences were noticed both in the susceptibility of different varieties of apple to disease and their liability to spray injury from the different sprays. Future spraying experiments will be largely influenced by the information obtained in this direction.

(4) Chilli diseases. The study of the diseases of chillies has been continued by Mr. Dastur.

Further experiments in the treatment of "die-back" caused by *Vermicularia Capsici* Syd. did not give any definite results. The methods adopted were preventive spraying, shade, and late sowing. There was a failure of the monsoon in September and October, and the consequent dryness of the air, at the time when the normal high humidity and the susceptible stage of growth of the plant usually combine to produce an outbreak, prevented the fungus from developing, and the crop remained free from attack. It was, therefore, impossible to judge of the effect on the disease of the various measures tried. However, it is evident that an attempt to avoid damage from this parasite by sowing a month later than the usual time, so that the susceptible period when flowering occurs may be delayed to the drier period of the cold weather, is not likely to be commercially profitable. The yield of fruits obtained from the late-sown crop was very poor. Similarly the interculture of *rahar* (*Cajanus indicus*) as a shade crop between the rows of chillies had the effect of stunting the latter and cannot be recommended. Further experiments on the same lines are being continued this year.

The blossom and twig rot of chillies, caused by *Choanephora cucurbitarum* (B. & Rav.) Thaxt., which was mentioned in last year's report as having done considerable damage in 1917-18, was not observed last year on a single

plant. This suggests that the disease is dependent on humidity, the chief difference between the two seasons being the abnormal dryness of that under report at the flowering period.

Some damage was done by a new chilli disease, the cause of which is unknown. It starts from the base of the forked branches and is characterized by a dull black discoloration of the green bark which travels up the limbs and down the main branch. The black bark later becomes chalky-white, the appearance being quite distinct from that caused by die-back. On the white portions raised blisters appear and these crack longitudinally. As a rule the injury is confined to those parts of the plant facing south. No organism has as yet been detected associated with the diseased condition. The effect on the plant is to cause the upper parts to shed their leaves and gradually die back.

(5) Pythium disease of ginger, tobacco and papaya. The work on this disease, commenced about three years ago by L. S. Subramaniam, Third Assistant, was completed to a stage justifying publication recently, and an account of it is now in the press as a Memoir.

The parasite was first isolated from tobacco and subsequently from ginger and papaya. In all cases it proved to be the same species and the strains from tobacco and ginger were each found capable of attacking the other two hosts. It has also been found in nature to cause a damping off of chilli seedlings, and artificial inoculations with cultures from tobacco and ginger gave successful infection of chilli, castor and potato. The strain isolated from papaya has hitherto only been tried on the same host, but from its similarity to the others, and the readiness with which these attack the papaya and produce the typical symptoms, it may be expected that the papaya fungus will also attack the other plants mentioned. There is, therefore, so far as the experiments go, no indication that the fungus possesses specialized races.

On tobacco and chilli the attack is a simple damping off, similar to that caused by *Pythium de Baryanum*. Large

number of plants are sometimes destroyed in the seed beds from this cause in the neighbourhood of Pusa. On older plants attack cannot be secured unless the humidity is maintained at a high level, and such humidities are not usually found at any but the early period of the growth of the crop in Bihar. Natural attack on plants subsequent to the seedling stage have not been observed.

On ginger the disease has long been known and its field characters and control were described by Mr. McRae in 1911. It causes a soft rot of the rhizomes and base of the stem in several widely-separated parts of India, and is a disease of much importance to ginger cultivation. As the underground parts are attacked, the disease is found during periods when the soil is moist, and is chiefly confined to the monsoon and early part of the dry weather following. It may thus last almost up to the time when the plants are fully grown.

On papaya the attack usually takes the form of a foot rot of the base of the stem at or just above ground level. Sometimes the stem higher up is affected. Large areas of soft rotting develop and the tree is often ultimately blown over. As before, the progress of the disease is usually confined to the rainy season.

The fungus on ginger was formerly identified by the writer as *Pythium gracile* Schenk, but these further studies have led Subramaniam to separate it from that species, and he has named it *P. Butleri* n. sp. It is evidently a widespread and, at times, destructive parasite in India.

Definite suggestions for its control have been made, and tested experimentally with good results, by Mr. McRae for ginger and L. S. Subramaniam for papaya. Attempts to check it in tobacco seed beds have proved less successful. Treatment of the soil with the ordinary antiseptics usually recommended has failed, but a treatment by burning dry grass on the surface was effective on a small scale. Further work in this direction is required.

(6) **Pigeon pea wilt.** Work on this disease was continued by the writer in collaboration with Mr. Finlow,

Fibre Expert to the Government of Bengal. It has been noticed during the last few years that the incidence of wilt in the permanent manurial experiments on the farm varies greatly in the different plots, being less in those that have received no manure and more in those that have had mineral fertilizers. This occurred in both series of the experiments and was too clearly marked to be accidental. Its examination has been taken up in the hope that it may throw some light on the obscure problem of resistance and susceptibility to fungous diseases in plants. The cropping hostory and soil composition of these plots are particularly well known, and they have received uniform treatment for the past eleven years, so that they are very suitable for the purpose.

Two possibilities suggest themselves: either the treatment of the plots has in some way altered the composition or characters of the host plant, or it has influenced the parasite. If the former, it should be possible to correct the deleterious effect of the mineral fertilizers by appropriate manurial treatment, since it is presumably nutritional. For this purpose a second series of permanent manurial experiments has been laid down and artificially infected so as to produce a heavy attack of wilt in all the plots in the first year. If the condition depends on some effect of the mineral fertilizers on the parasite (which is a soil fungus), it should be possible to detect this by regarding the soil as a culture medium and examining its effects on the vigour or virulence of the fungus. For this purpose pot cultures with soil from the permanent plots have been started and have already given some interesting results. Attempts have also been made, hitherto without success, to determine quantitatively the amount of the parasite in the soils of the different plots, and it is proposed to test the effect of the soil solution on the growth of the fungus. Mr. Finlow has meanwhile carried out a complete ash analysis of the plant from several of the plots. The root development under different manurial treatments is also being examined. It is not expected that definite results will be obtained before several years.

(7) Sugarcane smut. Mr. Dastur has investigated the mode of infection of the sugarcane smut, *Ustilago Sacchari* Rabenh. It has been found that direct infection of thin varieties of cane can take place only in two ways: (1) through the young tender "eyes" and (2) through the older "eyes" when they are wounded or injured. Thick cane varieties can only be infected in the latter manner, and this is evidently one of the causes of their relative immunity to smut. The infection has not been found to take place through the cut ends of setts or through adventitious roots. The hyphæ enter the "eyes" through the unthickened scale hairs, and have not been observed to penetrate the epidermal cells directly. Inoculated plants have given smutted shoots in two months, while setts cut from canes, the dormant eyes of which were infected in the autumn, gave rise to smutted stools when sown the following spring. This explains why setts taken from stools which show no external signs of the disease can, when planted, give a smutted crop. Further work is in progress but the results already obtained mark a decided advance in our knowledge of the ætiology of this important disease.

(8) Rangoon bean. The disease of the Rangoon bean (*Phaseolus lunatus*) originally erroneously reported in the press as due to *Phytophthora* was investigated by Dr. Shaw during the past year. The attention of the Department of Agriculture, Burma, was first drawn to this disease by a European planter engaged in agriculture in the Kyaukse District. It is not improbable that the disease is of long standing as even now Burmese cultivators are reluctant to report its presence and may have had it for years without the local agricultural authorities knowing of it. The recent increase in the area under Rangoon bean ("pebyugale") and the method of cultivation which is practised, may have increased the amount of the disease, but there is no means of judging of the extent of the trouble prior to the first report.

The increase in the area under Rangoon bean, consequent upon the rise in price of this commodity during the war, led to the crop being grown in situations in which it

would not otherwise have been laid down. In particular, mango gardens were cultivated with "pebyugale" under the trees, and in such shaded situations the disease seems worse.

The method of cultivation takes no account of the habit of *Phaseolus lunatus*. This plant is a climber. It is, however, hardly ever grown as such, but the seed is broadcasted on the field and the plant is left to form a straggling growth. The result of this, and of the heavy sowing rate, is to form a dense mat of vegetation, about 18″ or more thick, all over the field. Within this light and air cannot penetrate and humidity is very high. The conditions within such a mat of vegetation are ideal for the development of any fungus, and particularly for a fungus which makes its most active growth at relatively low temperatures as does the present parasite.

In a publication of the Burma Department of Agriculture (Leaflet No. 47) it is recommended that the crop be sown in lines $2\frac{1}{2}$ feet apart. Where this advice has been followed, little or no disease can be seen and the yield of beans is actually improved, as where the plants are widely spaced a far greater number of flowers are borne and come to maturity.

The fungus possesses large black sclerotia with a septate mycelium bearing a conidial stage in the genus *Botrytis*. Upon damp sand or moist corn meal the sclerotia will germinate and produce long stalk-like structures. So far these stalk-like structures have failed to produce any fructification. During the forthcoming cold season infections will be carried out on a number of different species of *Phaseolus*.

(9) Other diseases. The rotting of stored potatoes is a serious problem in several parts of India, both as affecting potatoes stored for seed and as restricting the supply intended for consumption. Dr. Shaw visited Poona in November to see the potato storing system worked out by the Bombay Department of Agriculture in co-operation with a private firm, and to advise on the methods adopted.

Some 900 tons of potatoes intended for Mesopotamia had been dealt with in this manner very successfully. A fieldman has been placed in charge of experiments carried out during the present hot weather in the Punjab. The whole subject was discussed at length at the mycological meeting in February, and the directions in which further work is desirable were brought out. It seems probable that progress will be difficult unless some method can be devised of storing the tubers at a lower temperature than that to which they are habitually exposed in the areas concerned.

Rust in wheat was first observed in Pusa on 23rd December, when a few plants were found infected with *Puccinia triticina*. By the middle of January there were plants with uredo sori scattered throughout the crop. The last week of January was cloudy and 1½ inch of rain fell on the 30th and 31st. This led to a moderately severe outbreak of orange rust, which brought out the varying susceptibility of the varieties on the farm to a marked degree, some being almost free from attack while the ground under others was brown from the shed spores. *Puccinia graminis* was first observed early in March and did relatively little damage. *Puccinia glumarum* was not seen at all, a most unusual circumstance at Pusa. The Australian Federation wheat proved highly resistant to both rusts, while Mundi of Jullundar, Makhai of Chiniot, Pusa 4 and Cawnpore 13 were highly resistant to orange rust.

Dr. Shaw's work on sclerotial fungi was continued. The two diseases of sugarcane from the Central Provinces, referred to in a previous annual report, appear to be identical with the diseases known as Het Zuur Rot and Het Rood Rot in Java. The latter form, or one very closely resembling it, has also been collected upon jute (*Corchorus olitorius*) at Rajshahi, Bengal.

Field experiments with the "tokra" (*Orobanche*) parasitic upon tobacco were continued. A crop of tobacco from seed of *Nicotiana rustica*, obtained from Peshawar, was grown in an infected field. In Peshawar District tobacco

is not infected with *Orobanche*, and it was thought that possibly seed from this locality might give an immune crop. Such, however, was not the case as the crop grown from Peshawar seed was just as badly diseased from *Orobanche* as the crop from local seed in the same field.

A comparative study of the species of *Helminthosporium* found on cultivated cereals and sugarcane at Pusa has been commenced. Practically every cereal grown here is attacked by one or more of these fungi, but it is already probable that some of them are common to several hosts and that the total number of species is not large. The work includes morphological study based on cultures as well as inoculation work to determine the range of host plants of each species.

Some work on a *Sclerospora* found on *Andropogon annulatus* in 1918 was carried out, with a view to getting a clue to the method by which the allied cereal downy mildews are transmitted. This is entirely unknown. No results have, however, as yet been obtained.

Comparative studies of some species of *Phytophthora* have given results of interest. The American species *Ph. terrestria* Sherbakoff has been found to agree with the earlier described Indian *Ph. parasitica* by Mr. Dastur. Recently both this and another species have been discovered attacking coconuts in Jamaica, and the latter has been found to be one of the causes of bud rot in the West Indies. Cultures sent to the writer have proved to be identical with his *Ph. palmivora* first described under the name *Pythium palmivorum* in Memoirs, Dept. of Agric. India, Bot. Ser., Vol. I, No. 5, p. 82, 1907. It is evident that one form at least of this most destructive West Indian disease is caused by the same organism which has been so fully studied in India, and an old controversy is thus settled in a manner satisfactory to us. Some work has also been done on the species of this genus found on rubber, and has strengthened the view held in this laboratory that the forms hitherto found on this host in India and Burma are all belonging to the one species.

V. Miscellaneous.

During the mycological meeting in February, the greatest interest was aroused by the demonstration of fungi parasitic on man and the higher animals by Captain Froilano de Mello, Director of Bacteriological Services, Goa. Captain de Mello worked in the laboratory for about a fortnight with material brought from Goa as well as some obtained locally, and was able to give a detailed demonstration of the technique required for the isolation and cultivation of these fungi.

Mr. S. N. Bal, Assistant Professor of Botany, Science College, Calcutta University, spent about a fortnight in the laboratory in March and April, as he proposes to take up mycological work in Calcutta. Mr. J. C. Nag, Senior Professor of Botany, Presidency College, Calcutta, also visited us with the same object in view, in June. Economic mycologists in India will welcome the increasing tendency towards the study of the subject in other than its economic bearings in Indian Universities, as there is a great field as yet but little explored in this direction. Large collections of named fungi were given to Mr. Bal, Mr. Nag, the Central Hindu College (Benares), St. Xavier's College (Bombay), Baroda College and the Government College, Lahore. Some Indian *Loranthaceæ* were also sent to Professor Weir in the United States, cultures of *Phytophthora* to various enquirers and some fungi parasitic on scale insects to the Government Mycologist, Ceylon.

During the year a development of great importance for the co-ordination of mycological work in the Empire took place. Proposals by the Imperial War Conference for the formation of an Imperial Bureau of Mycology to be situated in London were accepted, and the Government of India have agreed to subscribe £250 annually for three years in the first instance towards its cost. The lines on which such a Bureau could be of most use to mycologists in India were discussed at the meeting of Indian mycologists in February,

and a detailed note on the subject was submitted by the meeting to the proper authorities.

The writer has commenced the preparation of a systematic list of the fungi of India, as the references are at present so scattered that it is almost impossible to get a general view of the composition of the fungus flora of the country.

VI. Programme of work for 1919-20.

(1) *Research work.* New diseases of Indian crops that come to the notice of the Section will be investigated as opportunity permits, but the following diseases will receive special attention and will constitute main lines of investigation :—

(*a*) Ufra of paddy.
(*b*) Black band of jute.
(*c*) Chilli diseases.
(*d*) Fusarium wilts, especially in relation to soil and manurial conditions.
(*e*) Sclerotial diseases of jute, sugarcane, paddy and Rangoon bean.
(*f*) Orchard diseases.

Minor investigations will include the study of some fruit anthracnoses, *Orobanche* on tobacco, root rot of cotton, sugarcane smut, sal root rot and *Pythium* disease of papaya, ginger and tobacco.

(2) *Systematic work.* It is hoped to resume this with the facilities provided by the proposed Imperial Bureau of Mycology in London. Steps will be taken to supply the Bureau with representative collections from India. The preparation of a list of Indian fungi will be continued

(3) *Training.* This will be continued on the lines indicated in the prospectus.

(4) *Routine work.* Advice and assistance will be given to Provincial Departments of Agriculture and other departments and to the general public.

VII. Publications.

Butler, E. J. . . The Rice worm (*Tylenchus angustus*) and its control. *Mem. Dept. of Agric. India, Bot. Ser.*, Vol. X, No. 1.

Shaw, F. J. F. . . Report on Mycology, 1917-18, for the Board of Scientific Advice.

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REPORT OF THE IMPERIAL MYCOLOGIST.

(E. J. Butler, D.Sc., M.B., F.L.S.)

I. Charge and Establishment.

I held charge of the Section throughout the year, except for the period from 1st May to 17th June, 1920, when I was appointed sub. *pro-tempore* Agricultural Adviser to the Government of India and Director of the Agricultural Research Institute, Pusa. Mr. G. P. Hector, Officiating Imperial Economic Botanist, held charge during this period. The work as Joint Director was unusually heavy last year owing to the development of proposals for the expansion of the Agricultural Research Institute and the revision of pay of establishments due to changed conditions after the war, and left little time for mycological work. The Section further suffered by the absence of Mr. Dastur, Supernumerary Mycologist, on deputation to England from the end of August 1919, and of Dr. Shaw, Second Imperial Mycologist, on leave from 5th February, 1920.

Towards the end of the year I was appointed Director of the Imperial Bureau of Mycology in London, and leave shortly to take up this post, Mr. W. McRae, Government Mycologist, Madras, succeeding me as Imperial Mycologist.

Mr. M. Mitra, M.Sc., who entered the Section as a private student last year, was appointed First Assistant from 1st April, 1920.

II. Training.

In addition to Mr. M. Mitra, mentioned above, Pandit S. D. Joshi, a private student from the United Provinces, continued his post-graduate course and was granted a stipend by his Local Government. Mr. T. Padmanabha Pillai, Mycologist, Travancore State, worked at laboratory methods during a period of one month from 5th February, 1920.

III. Diseases of Plants.

(1) Black band disease of jute. The research work on this disease was continued by Dr. Shaw. In Bihar, in 1919, the state of the jute crop was similar to that in 1918. A considerable portion of the seed-crop had, however, been sown as late as June and this was invariably clean and healthy. This confirms the observations made last year from the infection of the crop all over Bihar that the late sown crop is relatively immune. In the more early sown areas the crop was only slightly diseased and not to an extent which would seriously diminish the yield. The condition of the crop on the Dacca Farm by no means agreed with that in the previous season. Both the green and the red-stemmed varieties of *Corchorus olitorius* were attacked. The incidence of the disease was not heavy and varied considerably in different fields on the farm. The greatest damage seen in any one area was probably about ten per cent. The red-stemmed *C. capsularis* was also attacked. These observations are quite sufficient to show that neither the red-stemmed varieties of *C. capsularis* nor of *C. olitorius* were resistant to the disease. At Chinsurah Farm where the jute consisted of the same red and green varieties as at Dacca, the crop was very fine, averaging about 14 feet in height, and there was not a single case of black band. At Rangpur the crops of both *C. olitorius* and *C. capsularis* were infected. The disease, however, only reached an appreciable degree when the plants were of a certain size.

Infection experiments carried out both on plants in pots and on plants in the field showed that though red varieties of *C. capsularis* and *C. olitorius* are by no means immune yet under the conditions of the experiments they seem less susceptible. A large number of experiments carried out on green *C. capsularis* showed that the number of successful infections depended on the humidity of the air at the time of experiment and the exact determination of the conditions is a point for further investigation.

The field experiments carried out in 1918 with the object of throwing light on the conditions affecting the spread of the disease were repeated.

1. Two plots (A and C) were sown with seed of green-stemmed jute about 5th March, the former with treated and the latter with untreated seed. The land had carried jute which was slightly drained the previous season but had not been under jute previously for 25 years. *D. Corchori* was practically absent in both plots; only some 3 or 4 cases could be seen.
2. In similar plots (B and D) a crop of *C. olitorius* and of red-stemmed *C. capsularis* also remained free from the disease.
3. Two plots (E and F), each about $\frac{1}{4}$ acre, situated in a portion of the field in which jute had some disease the previous year and was particularly bad the year before, were sown with seed of green-stemmed jute. The seed was steeped in a solution of copper sulphate. Germination was scanty and both plots were resown on 4th July after the commencement of the rains, and gave a crop of typical late sown jute, short in height and thin in stem. In both plots the number of stems infected with *D. Corchori* was negligible, only about 12 cases could be found when the crop was cut early in November.
4. Of two plots (H and K) about $\frac{1}{3}$ of each plot was sown on 5th March with a red-stemmed and the remainder with a green-stemmed variety of *C. capsularis*. These plots were situated in the land which had carried the diseased jute in 1918. Both the varieties of seed sown had been steeped in 2 per cent. copper sulphate. Plot H carried a very scanty crop and had 31 cases of *D. Corchori* among the green-stemmed and only 6 cases in the red-stemmed variety. In plot K the crop was much thicker, both germination and growth having been better than in plot H. In plot K there were 190 cases of *D. Corchori* among the green-stemmed and 34 cases in the red-stemmed variety.

5. Plots (M and N), each about $\frac{1}{4}$ acre, were selected in good land which had never carried jute before. Plot M was sown on 5th March with seed of green-stemmed variety which had been treated by steeping in copper sulphate solution, and plot N was sown on the same date with seed which had not been so treated. Both plots gave an excellent crop of jute, 9—11 feet in height. In both plots nearly the same number of stems were diseased owing to *D. Corchori*—76 stems in Plot M and 56 in Plot N.

As a result of these field experiments, particularly from a consideration of the last two plots, it cannot be said that seed steeping in copper sulphate has any influence on the severity of the disease, and, therefore, as mentioned above, the dissemination of the disease cannot take place to any appreciable extent through spores of *D. Corchori* mingled with the jute seed. The percentage of disease was also not to any extent greater in those plots which had been under jute for two or more successive seasons. Steeping the seed may then be discontinued.

An account of the work done on this disease during the last three years is now in the press as a Memoir.

(2) **Fruit work in Kumaon.** The season's practical work for 1919 was completed in July. The chief diseases dealt with were apple mildew (*Podosphæra*), which most nearly approaches epidemic conditions in these orchards, branch blister and apple cracking due to *Coniothecium chomatosporum*, fly speck and sooty blotch (*Leptothyrium Pomi*), and peach leaf curl (*Exoascus deformans*).

The apple mildew spraying series included a test of home-made lime sulphur, Berger's lime sulphur, and Burgundy mixture, lead arsenate being added in each case. The trees stood even the "winter" strength of lime sulphur successfully and the experiments showed that an application of this fungicide made at the proper time will largely control the disease. Berger's mixture proved very satisfactory and simple to use. Further experiments with iron sulphide

are, however, required before deciding on lime sulphur as the routine treatment.

For the *Coniothyrium* disease the same sprays were used. In general the superiority of the fruit on the sprayed rows was very marked. The home-made lime sulphur and Berger's mixture both gave good results and did no damage to the trees. Burgundy, however, caused so much damage to fruit and leaves as to be largely a failure. This bears out recent work in English orchards with this mixture.

There was little *Leptothyrium* present but the trees sprayed with lime sulphur and Burgundy had certainly less than the others. Burgundy injury was again marked. Peach leaf curl was entirely controlled by all three sprays.

The variation between different varieties in susceptibility to disease as well as in resistance to Burgundy injury is so marked that it is useless to expect comparative results unless the tests are made on the one variety. Northern Spy is so susceptible to mildew that it is being discarded on at least one estate. King of the Pippin was immune to *Coniothecium*. Burgundy injury was very bad on Cox Orange Pippin and the leaves were scorched on Esopus Spitz, while King of the Pippin was quite free from it.

I visited Ramgarh in October with Dr. Shaw and discussed future work on the spot. The proprietors of the Allen Orchard are kindly placing at our disposal a small building for mycological work. Owing to Dr. Shaw's absence no new experiments have been carried out in the 1920 season.

(3) Cereal diseases. It has long been apparent to mycologists in India that there is a large group of parasites belonging to *Fusarium*, *Helminthosporium* and allied genera which attack cereals throughout the country. Some of these, such as the stripe disease of barley, are well known in other countries, others appear to be peculiar to India or at least have not been previously described. Mr. M. Mitra took up the study of the species allied to *Helminthosporium* and has made considerable progress in this enquiry, which is likely to extend over several years.

Species of *Helminthosporium* were found commonly attacking maize, *jowar* (*Andropogon Sorghum*), *bajra* (*Pennisetum typhoideum*), rice, wheat, oats, barley, and sugarcane. In every case the chief attack is on the leaves, and excepting the stripe disease of barley the symptoms are on the whole very similar.

The parasite concerned was isolated from each of the above hosts and grown in pure culture for comparative study. Wheat was found to have a considerable range of forms on it in different parts of India. They appear to be related to *H. teres* Sacc. On rice the common species appears to be *H. Oryzæ* Hori, previously described from Japan. *H. turcicum* Pass. occurs on maize and *jowar* but freely grows also on wheat, oats, barley, and sugarcane. It does not attack *bajra* and only rarely rice. The species on sugarcane and rice attack all the hosts on which they have been tried whereas the wheat and barley species give reciprocal successful results. Further work on these lines is being done.

An allied genus, *Acrothecium*, is parasitic on several of the *Gramineæ* and one species attacks *bajra* at Pusa somewhat severely. It is a new species, which has been named *Acrothecium Penniseti*. The attack is on leaves, leaf-sheaths and ears, the leaf-form being the commonest but the ear attack probably doing most damage. The spikelets are attacked in clusters and the grain aborted. The attack is, as with so many other fungus diseases at Pusa, closely dependent on the atmospheric humidity.

The parasite has been isolated and studied in artificial culture by Mr. Mitra who has written a detailed account of it, now in the press as a Memoir. It is a vigorous parasite, with general points of similarity to other parasites of allied genera. It can attack maize ears but not the leaves; *jowar* is immune.

A second species, *Acrothecium lunatum* Wakker, is common at Pusa on maize and *jowar*, as well as on several wild grasses. It appears to do a good deal of injury to the male inflorescence of the former, where it is sometimes

associated with *Acrothecium falcatum* Tehon, but it is only a weak parasite on *jowar*. It is capable of attacking young leaves of *bajra* to some extent. Another form is found on rice. All these are being studied in pure culture.

Last season we received a number of reports and specimens of disease in wheat with the general symptoms of the foot rot disease which has attracted so much attention in the United States in recent years. As in that country a group of fungi seems to be responsible. The three fungi so far found in India are *Rhizoctonia destruens*, a *Pythium* of the *gracile* group, and a *Fusarium*. Of these the last is the most destructive, the other two being responsible in a limited number of cases only. All three fungi were isolated in pure culture by Mr. L. S. Subramaniam and successful inoculations were obtained with them on wheat grown at Pusa.

(4) **Pythium disease of ginger and other crops.** A Memoir describing fully this disease was published by Mr. L. S. Subramaniam during the year. As the work was summarized in last year's report it need not be further referred to here.

(5) **Potato storage rots.** Considerable attention has been given to the study of the means of preventing rotting of potato tubers during the hot weather and rains. Complaints of heavy losses from this cause leading to an excessive price of "seed" tubers at planting time, have become very frequent of late. A series of experiments was conducted at Sialkot in collaboration with the Punjab Department of Agriculture.

In storing potato tubers a two-storeyed well-ventilated house was selected and fumigated with sulphur vapour. Two sorts of tubers were selected: (*a*) from fields where potatoes were grown as ordinary routine crop, (*b*) from fields where potatoes were grown for the first time. The selected potato tubers were then put into sterile gunny sacks and fumigated with petrol vapour for 24 hours. Some of these fumigated potatoes were

stored (1) in dry sand, (2) in sacks loosely packed, and (3) on racks made of wooden battens. The rest of the fumigated potatoes were treated in corrosive sublimate solution (1 in 2,000) for 1 hour and afterwards taken out and dried and were stored exactly in the above manner. The experiment lasted during May and June 1919. The year being exceptionally trying on account of the excessive heat, potatoes started rotting very soon and in every case the bulk of the potatoes became rotten.

These results bear out the conclusion previously come to that the rot is primarily a result of excessive temperature and that it will be difficult, if not impossible, to check unless some form of cool storage can be devised. The natural suggestion is storage in the hills (at present a large proportion of the plains crop is from hill-grown seed and it should be possible to develop this by improving transport facilities and cheapening freight) but the alternatural suggestion is storage in the hills (at present a Further work is required so as to get a more exact knowledge of the temperature limits at which storage may be expected to pay.

(6) **Root rot of cotton.** The writer visited Lyallpur in October 1919, to make a further attempt at diagnosing the cause of this disease. Previous efforts at Lyallpur and Hansi had been unsuccessful, the causes then assigned not standing the test of more exact observations and experiments. The conclusion arrived at on this last visit is that the disease is a non-parasitic one which is associated with some unknown soil condition. Further work will probably have to be taken from another side than the mycological. The disease occurs sporadically through most of Northern and Western India.

IV. Systematic work.

A good deal of progress was made in the preparation of a fungus flora of India, so far as the materials at present exist. The total number of recorded species is probably under 2,000 which is certainly not one-fourth of those that

exist. It is hoped to continue this work as opportunity permits.

An interesting paper has recently been published in the Philippines which gives evidence to support the view that the bud rot of coconuts is caused by the same fungus that causes canker of rubber and cacao and is usually known as *Phytophthora Faberi* Maublanc. If this is correct and the cause of bud rot in the Philippines is the same as in India this fungus will rank as one of the most destructive known. Its Indian name, *Phytophthora palmivora*, has priority over that given above.

V. Programme of work for 1920-21.

(1) *Research work.* New diseases of Indian crops that come to the notice of the Section will be investigated as opportunity permits, but the following diseases will receive special attention and will constitute main lines of investigation :—

(*a*) Black band of jute.
(*b*) Chilli diseases.
(*c*) *Fusarium* wilts, especially in relation to soil and manurial conditions.
(*d*) Sclerotial diseases of jute, sugarcane, paddy, and Rangoon bean.
(*e*) Orchard diseases.

Minor investigations will include the study of some fruit anthracnose, *Orobanche* on tobacco, root rot of cotton, sugarcane smut, *sál* root rot, and *Pythium* disease of papaya, ginger and tobacco.

(2) *Systematic work.* It is hoped to resume this with the facilities provided by the proposed Imperial Bureau of Mycology in London. Steps will be taken to supply the Bureau with representative collections from India. The preparation of a list of Indian fungi will be continued.

(3) *Training.* This will be continued on the lines indicated in the prospectus.

(4) *Routine work.* Advice and assistance will be given to Provincial Departments of Agriculture and other Departments and to the general public.

VI. Publications.

Butler, E. J. . . Report on Mycology, 1918-19, for the Board of Scientific Advice.

Subramaniam, L. S. . A *Pythium* Disease of Ginger, Tobacco and Papaya. *Mem. Dept. of Agri. in India, Bot. Ser.*, Vol. X, No. 4, December 1919.

Shaw, F. J. F. . Studies in Diseases of the Jute Plant. (1) *Diplodia Corchori* Syd. *Mem. Dept. of Agri. in India, Bot. Ser.*, Vol. XI, No. 2. (*In the press.*)

Mitra, M. . . Morphology and Parasitism of *Acrothecium Penniseti* nov. spec. (A New Disease of *Pennisetum typhoideum* Rich.) *Mem. Dept. of Agri. in India, Bot. Ser.*, Vol. XI, No. 3. (*In the press.*)

REPORT OF THE DIRECTOR, AGRICULTURAL RESEARCH INSTITUTE AND COLLEGE, PUSA, FOR THE YEAR 1909-1910.

(E. J. BUTLER, M.B., F.L.S.)

1. *Charge of Office.*—Mr. B. Coventry held charge of the office of Director up to the 9th May 1910, with the exception of one month in September-October 1909, when he was on privilege leave and Mr. H. Maxwell-Lefroy, M.A., F.E.S., F.Z.S., Imperial Entomologist, acted for him during his absence in addition to his own duties. In consequence of his appointment as Officiating Inspector General of Agriculture in India, Mr. Coventry relinquished charge of the office of Director on the 9th May 1910, and I was appointed to officiate for him in addition to my own duties.

2. *Staff.*—Dr. J. Walter Leather, Ph.D., F.I.C., F.C.S., Imperial Agricultural Chemist, returned from leave on the 27th October 1909 and took over charge of the chemical section from Mr. H. E. Annett. The latter has been deputed to act as Agricultural Chemist, United Provinces, from the 3rd November 1909. The charge of the mycological section was taken over by me from Mr. W. McRae, M.A., B.Sc., on the 27th December 1909, when I returned from leave, and immediately after Mr. McRae proceeded to Madras to join his new appointment as Mycologist to the Government of Madras. His successor, Mr. F. J. F. Shaw, B. Sc., A.R.C.S., joined his appointment as Supernumerary Mycologist on the 28th January 1910. Mr. C. W. Mason, Supernumerary Entomologist, left the Department on the 19th December 1909, and Mr. T. Bainbrigge-Fletcher, R.N., F.E.S., joined this Institute as Supernumerary Entomologist on the 8th April 1910. The Second Imperial Entomologist, Mr. F. M. Howlett, B.A., F.E.S., has been on leave since the 9th September 1909 and

is expected to return in January next. Mr. C. M. Hutchinson, B.A., joined the Department on the 24th December 1909, as Imperial Agricultural Bacteriologist. The charge of the Farm was relinquished by Mr. E. Shearer, Imperial Agriculturist, on the 17th July 1909, in consequence of his promotion to the post of Assistant Inspector General of Agriculture in India and the Director was placed in charge of the duties of the Imperial Agriculturist in addition to his own duties. Mr. G. C. Sherrard, B.A., Supernumerary Agriculturist, was appointed to be Assistant Agriculturist with effect from 17th July 1909. He was on privilege leave from 2nd to 20th November 1909, and from 6th June 1910 to 6th July 1910. Mr. A. McKerral, M.A., B.Sc., who has been appointed Assistant Inspector General of Agriculture in India, *vice* Mr. E. Shearer, resigned, has been lent to the Pusa staff to undertake the work of Imperial Agriculturist under the Director as a provisional measure. He joined his duties at this Institute on the 19th June 1910. The botanical section was in charge of Mr. A. Howard, M.A., A.R.C.S., F.L.S., up to 30th April 1910, when he proceeded on leave to England. Mr. G. P. Hector, M.A., B.Sc., Supernumerary Botanist, was transferred to Eastern Bengal and Assam on the 14th July 1909, and the services of Mr. E. Holmes-Smith, B.Sc., Economic Botanist designate of Burma, were transferred to this Department with effect from the 15th July 1909, for appointment as Supernumerary Botanist. The latter has been on deputation in the Bombay Presidency since the 6th March 1910, to acquire experience of work in a province.

The European Scientific Staff of the Institute consisted of the following :—

(1) The Imperial Agricultural Chemist with one Supernumerary, (2) the Imperial Mycologist with one Supernumerary, (3) the Imperial Entomologist with one Supernumerary, (4) the Imperial Economic Botanist with one Supernumerary, (5) the Second Imperial Entomologist, (6)

the Imperial Agricultural Bacteriologist, (7) the Assistant Inspector General of Agriculture in India (temporarily in charge of the agricultural section) with the Assistant Agriculturist.

During the year under report, the pay and position of several of the senior Indian assistants of the institute were improved and the first assistants in each section as well as other assistants engaged in teaching and research work have been admitted to gazetted rank.

3. *Scientific Work.*—The scientific work of the Institute during the year is indicated in the reports of the various Sections.

4. *Buildings, Grounds, etc.*—In consequence of the transfer of the head-quarters of the Inspector General of Agriculture in India to Pusa, two blocks of new quarters have been departmentally constructed for the use of his staff and in addition some old buildings have been placed at his disposal. The grounds surrounding the College building have been fully laid out and arrangements made for irrigating the lawns.

5. *Students.*—Out of the students admitted in the previous year, 9 continued their course and of these 7 left during the year after the completion of their training and one was recalled to his province before the expiry of his term. Four new students were admitted during the year, *viz.*, one in Chemistry (an Assistant of the Agricultural Chemist, United Provinces) for a three months' course, one in Mycology (a private student from Bombay), one in Entomology, from the Central Provinces Department of Agriculture, and one for a general course in Agriculture from the Punjab Department of Agriculture. The private student in Mycology has, however, abandoned the course and left the Institute. There were at the end of the year four students under training, *viz.*, one in Chemistry, two in Entomology and one for a general course.

The short courses in practical agriculture and in other allied practical subjects inaugurated last year at Pusa

were continued. The number of students admitted to the various sections for these courses was as follows:—Six in fruit-growing, eighteen in silk-culture, ten in lac cultivation, nine in cattle breeding and management, three in poultry management and three in tillage implements and agricultural machinery. The students for these courses came from different parts of India and some of them took up more than one subject.

6. *Publications.*—This work has been continued. During the year under report two new books, one "Indian Insect Life" by Mr. H. Maxwell-Lefroy, Imperial Entomologist, assisted by Mr. F. M. Howlett, Second Imperial Entomologist, and the other "Wheat in India" by Mr. A. Howard, Imperial Economic Botanist, and Mrs. Howard, were published in addition to the Agricultural Journal of India, the Memoirs of the Department of Agriculture in India, Bulletins and Leaflets.

7. *Library.*—The revised catalogue of the library is still in the press. Over a thousand volumes have been added to the library during the year.

8. *General Health of the Station.*—The general health of the station during the year under report was good, excepting in the monsoon period. Relief was afforded in the hospital to 6,231 new cases, of which 6,015 were treated in the outdoor department and 216 admitted as indoor patients. These figures show an increase of 2,918 and 112 respectively over last year's totals. The increase in attendance was due to the greater prevalence of malarial and allied fevers during the months of July, August and September, 1909. 99 cases amongst European officers and their families were attended to.

The daily average number of patients treated was 6·96 indoor and 48·97 out-door as against 4·68 and 25·05 respectively during the previous 12 months.

Five deaths occurred in hospital—two cases from pneumonia in aged and debilitated subjects, one from malarial cachexia and two from *Kala-Azar*.

Eighty-eight surgical operations were performed, of which 4 were major and the remainder minor.

The prevailing diseases were malarial fevers, bowel complaints and rheumatic and skin affections. Malarial fever cases were diagnosed microscopically before treatment.

There were no cases of infectious diseases, except a case of chicken-pox (imported). Eight primary and three revaccinations were performed in the early part of the year.

9. *Accounts.*—The total expenditure incurred during the year was Rs. 3,12,427 as against Rs. 3,23,900 of the preceding year. The principal items of expenditure are pay of gazetted officers and establishment Rs. 1,78,680, travelling allowance of officers and establishment Rs. 14,699, publications Rs. 30,000 and farm expenditure, scientific apparatus, books, contingencies, etc., Rs. 89,048.

The gross receipts during the year by sale of farm produce, milk and other miscellaneous articles amounted to Rs. 5,573 as against Rs. 9,680 of the preceding year. The decrease is due to the abnormal rainfall (amounting to 72 inches) which damaged the crops.

Report of the Agricultural Research Institute and College, Pusa,

(*Including Report of the Imperial Cotton Specialist.*)

1910-11.

REPORT OF THE DIRECTOR, AGRICULTURAL RESEARCH INSTITUTE AND COLLEGE, PUSA, FOR THE YEAR 1910-11.

(E. J. Butler, M.B., F.L.S.)

1. *Charge.*—I held charge of the office of Director, Agricultural Research Institute, and Principal of the Agricultural College, Pusa, throughout the year, in addition to my duties of Imperial Mycologist.

2. *Staff and work of the Institute.*—The Institute is organised in seven scientific sections, Agricultural, Chemical, Botanical, Mycological, Entomological, Second Entomological, and Bacteriological, the detailed reports of which are given in the body of this report. For much of the period under review, the superior staff was below strength. Towards its close, three supernumerary officers were absent on deputation or filling leave vacancies in the provinces; the Imperial Entomologist was on long leave; the Assistant Agriculturist's post was vacant; while I occupied the dual posts of Director and Imperial Mycologist. Thus, there were only eight European officers of the Pusa staff actually at work for the Imperial Department, and of these two (the Imperial Economic Botanist and his Personal Assistant) were engaged in Baluchistan, developing the

fruit industry of that province, in addition to their own duties.

The following summary gives very briefly the organisation of the staff, and the main lines of work of each section during the year.

3. *Agriculture.*—Mr. A. McKerral, Assistant Inspector General of Agriculture, was lent to take charge of the farm up to the 17th November, 1910, when Mr. G. Sherrard, Assistant Agriculturist, took over all except the work in connection with cattle and poultry breeding, which remained under Mr. McKerral until February, 1911. Mr. Sherrard held charge up to the 16th June, 1911, when he was appointed Professor of Agriculture, Bengal Agricultural College, Sabour, and Mr. A. C. Dobbs, Assistant Inspector General of Agriculture, was lent to take charge, pending permanent arrangements. Mr. H. Southern joined the staff as Supernumerary Agriculturist on the 29th November, 1910, but left again on the 13th February, 1911, to officiate for Mr. Simpson, Deputy Director of Agriculture, Southern Circle, Madras, who was about to proceed on leave.

Notwithstanding these frequent changes, and in spite of the fact that since February the farm has been managed by only a single officer, steady progress continues to be recorded. The *rabi* sowings were completed at an earlier date than any previous year, and the harvest was exceptionally good. A yield of 33 maunds of oats per acre was obtained from one field, and a record was established in threshing, 241 maunds of oats being threshed in one day with the steam thrasher. The rains set in early in June, 1911, and most of the *kharif* crops were sown before the end of the month and give excellent promise. Against this, the *kharif* of 1910 was marked by extensive floods in Behar, and a large part of the crops on the lower lands was lost owing to a breach in the protective embankment.

The experimental work on the farm suffered from the floods in the monsoon of 1910, one block of the permanent manurial and rotation experiments having been completely

destroyed. The duplicate block on higher land, however, escaped. It is too early to expect results from these experiments. The permanent pasture experiments were abandoned during the year, after full consideration of the results to date. It is evident that the improvement of pasture land will have to be attempted on different lines, and a modified plan of experiment is under consideration. A comprehensive series of manurial experiments with flax was started by the Fibre Expert to the Government of Eastern Bengal and Assam, in collaboration with the Inspector General of Agriculture, but an outbreak of dodder necessitated the destruction by burning of the whole crop. Flax dodder is not indigenous to India, and there is no doubt that every effort should be made to keep it out in future, and to destroy what was introduced in the past. Experiments with jute and paddy were continued, the former according to plans drawn up by the Fibre Expert. As the area under arable cultivation is now more than sufficient to provide fodder and grain for the breeding herd and work cattle, it is hoped to extend experimental work in the near future. A considerable part of the farm is devoted to crops grown for the other sections for observation and experiment.

The farm stock have done well. The Montgomery herd has been increased by natural growth and purchase. Proposals for a dairy were submitted during the year, but sanction has been withheld for the present. There is an undoubted demand for instruction in dairying, and with the large herd of excellent milch cattle now being formed at Pusa, a dairy will ultimately prove an essential part of the equipment of the Institute. The management of the poultry has been in the hands of the Inspector General of Agriculture for the greater part of the year.

I wish to record my appreciation of Mr. Sherrard's work not only on the farm, but in assisting me in the general management of the Estate.

4. *Chemistry.*—Dr. Leather held charge throughout the year. Mr. Annett, on the termination of his acting ap-

pointment as Agricultural Chemist, United Provinces, and on expiry of his privilege leave, resumed charge of his duties as Supernumerary Agricultural Chemist at Pusa on the 11th November, 1910. He has been since appointed to act as Principal of the Agricultural College, Cawnpore, and left Pusa to join this appointment on the 24th June, 1911.

The important investigation on the water requirements of crops in India, to which allusion has been made in previous reports, has advanced a stage, and a second memoir on the subject has been published by Dr. Leather. The principal conclusions arrived at are, that the nature of the soil has no effect on the transpiration ratio, but profoundly influences the rate at which water can move through the soil, and hence the total weight of crop produced. Also, that practically the whole of the water used by a crop is obtained within the root range, some 6 to 7 feet in alluvial soil, the large stores of water below this depth being substantially of no service to the plant.

Drain gauges to test the quantity and composition of the subsoil drainage water from arable land were erected some years ago at Cawnpore and Pusa, and the results of several years' records are now in the press. They yield information of the greatest interest on some of the factors which must always fundamentally influence Indian agriculture, when compared with that of temperate climates. Thus it has been found that the loss of water from bare fallow soil is almost constant year by year in any one place, and is at Pusa nearly double that at Rothamsted in England. At Cawnpore, on the other hand, it is little more than at Rothamsted, and this difference between Pusa and Cawnpore requires to be explained but probably depends on the nature of the soil. The protective influence against evaporation due to the presence of a crop has been approximately determined for different periods of the year. The amount of nitrate present in the drainage water from fallow land is very much greater than at Rothamsted, twice or three times as much, and nitrification occurs with

great vigour after the first heavy rain of the monsoon, but is not active during the dry months.

Dr. Leather has continued his investigation of *usar* land, with special reference to its physical state. He has also, in consultation with the Director of Agriculture, and the Irrigation Department, United Provinces, carried out the first stage of a comprehensive experiment directed to determine once for all whether, as is frequently stated, irrigation leads in certain lands to an increase of alkali.

Mr. Annett is engaged on a general investigation of the Date Palm sugar industry, a very important Indian industry, about which little accurate information is available.

An improved method of refining crude saltpetre was devised by Dr. Leather, and has been described in a Bulletin recently published. More nitrate is obtained than by the ordinary methods in use, the product is of higher quality, less fuel is required, and the process is independent of the weather. Its financial possibilities, however, remain to be demonstrated, and arrangements have been made to test the method on a commercial scale this year.

5. *Botany.*—Mr. Howard resumed charge of this section, on the expiry of privilege leave and deputation in England, on the 29th July, 1910. He was deputed to advise the Kashmir Durbar on hop cultivation from the 1st August to the 27th September, 1910. During his absence Maulvi Abdur Rahman Khan, Second Assistant, held charge of the current duties of the section. Mrs. Howard, who has ably assisted her husband during the past five years, was appointed Personal Assistant for three years from the 1st October, 1910. Mr. E. Holmes Smith, Supernumerary Economic Botanist, was on deputation in the Bombay Presidency throughout the year. He leaves the Department on the expiry of his agreement in October, 1911. Mr. Howard has been placed in charge of a scheme to develop the fruit industry of Baluchistan, in addition to his own duties, for a period of three years from the 1st May, 1911. He will work in Baluchistan for five months, from May to September, each year.

During his absence in England, Mr. Howard carried out some experiments in the production of rust resistant wheats suitable for India, and studied the trade requirements for improved Indian wheat and tobacco. He also enquired into modern methods of hop cultivation and drying and fruit packing, with a view to utilising the information on his return to India.

The possibilities of hop growing in Kashmir are apparent, when it is learnt that with a production per acre of one-fifth of that of Kent, an annual average profit of over £7 per acre has been realised on the Government hop garden, for the last sixteen years. In Mr. Howard's report to the Durbar, the directions are indicated in which improvements are possible, if it is decided to continue the industry on the present lines, and also the steps which are necessary if hop growing in Kashmir is to be placed on modern lines and if Kashmir is to enter the markets of the world as a competitor with California.

Perhaps the most important work on which Pusa is engaged at present is the improvement of Indian wheat. The lines on which this is being carried out have been sufficiently indicated in previous reports of the Botanical Section. The best Pusa wheats produced in 1910 were shown at Mark Lane, and on the Liverpool Corn Exchange, while Mr. Howard was in England, and were acknowledged to be without any superiors on the market at the time. During the past year, the high grain-quality of some of the best of these types has been combined with the high yield of low-quality Indian wheats, as a result of hybridization. The demand, both in India and abroad, for some of the improved wheats produced at Pusa has been far in excess of the supply. It is estimated that over 1,000 acres of the new wheats will be sown in Behar this year. At Raipur and Cawnpore, some of these wheats have proved equally successful, and extended trials have been arranged for at a number of other stations in the wheat-growing tracts of India. Mr. Howard is careful to point out that the full benefit of improved varieties can only be realised if cultiva-

tion is good and moisture is adequate. Disappointment is bound to result, if the influence of these two all-important factors in crop production in India is disregarded.

The improvement of tobacco is being carried on on similar lines to that of wheat. Both in yield and quality of leaf very encouraging results have been obtained.

The botanical study of certain fibres was continued, the isolation of the varieties of *san* (*Crotalaria juncea*) and *patwa* (*Hibiscus cannabinus*), and their improvement by selection and crossing, being the principal work in progress in this direction.

Further work on pollination in important crops of India was carried out, and a Memoir published giving the data for a number of crops.

Towards the end of the year, the lines of work on the improvement of the fruit industry of Baluchistan were developed, and the site of a new Experimental Station for the purpose selected near Quetta.

6. *Mycology.*—I held charge of this section during the year, in addition to the office of Director. Mr. Shaw continued to hold the post of Supernumerary Mycologist.

Much time was given to systematic work, as it was found that progress in Indian economic mycology was greatly hampered by the difficulty in determining the identity of the fungi of the country. All the specimens of one of the larger groups, the Ascomycetes, were worked through and annotated lists were published after the close of the year under review.

The charge of the campaign against palm disease in Godavari and Kistna Districts was taken over by the Madras Mycologist in 1910. It is being continued on the same general lines as before. A full account of the disease, and of the campaign against it carried on since 1907, was written by me and published as a Memoir in September, 1910. The conclusions arrived at are that the operations have been entirely successful in limiting the disease in Godavari to the area previously infected: the work in Kistna was started later, but the progress is encouraging

in this district also. The effect of the work in reducing the severity of the disease within the infected tract was not easy to estimate when the report was written, but with the further records since available it appears that a distinct decrease in the mortality is noticeable at the present time. If the disease can be effectively confined to the existing limits, the outlay incurred will be amply justified, and there is every reason to hope that the continuation of the work will lead to its being gradually stamped out altogether.

The need for a mycologist to work specially on the diseases of the tea plant has become increasingly apparent, and the Indian Tea Association have decided to add an appointment of this nature to their Scientific Department. Meanwhile, Pusa gives such assistance as is possible. Mr. McRae's Bulletin on blister-blight in Darjeeling, published at the beginning of the year, indicates the lines on which the control of this dangerous blight should be attempted. Many planters are experimenting on these lines, but the disease is firmly established and still spreading; unless a cheap and effective method of lessening its ravages can be worked out, there is every reason to fear that the result will be a permanent and considerable reduction of the Darjeeling tea crop. The copper-blight of tea was described by Mr. Shaw, the parasite which causes it not having been previously known to occur in India. A disease of tea seed was investigated by me, and shown to be probably associated with an insect which punctures the seed, and so admits rotting fungi to the tissues of the interior. It is believed that this insect can be fairly easily destroyed.

Other diseases investigated by the section, of which accounts were published during the year, were soft rot of ginger (by Mr. McRae), turmeric leaf spot (by myself), and heart rot of the blue pine (by Mr. Hafiz). Forest diseases, of which the last named is an instance, cause great losses in India; Pusa gives such assistance as it can to the Forest Department, but there is room for a mycologist to work specially at these diseases.

Mr. Shaw is engaged in investigating the root rot of a number of cultivated plants, caused by a species of Rhizoctonia. The parasite appears to be the same in all cases and its complete study, in view of the large range of its victims, is most desirable.

The usual routine work of advising cultivators and the general public interested in agriculture on the diseases of plants and allied matters, which in this section, as in the Entomological, forms a very essential part of the work, was continued. Assistance was also given to Provincial Agricultural Departments in advising on the work of their Mycological assistants, and in providing material for reference collections in their colleges.

7. *Entomology.*—Mr. Lefroy held charge of this section up to the 31st January, 1911, when he proceeded on leave, and Mr. T. Bainbrigge Fletcher, Supernumerary Entomologist, took over charge.

As in previous years, several provinces have freely availed of the assistance offered by Pusa in co-ordinating and checking the work of their Entomological assistants. Of these latter there are now seventeen, some engaged in teaching at the six Provincial Agricultural Colleges, the others in field work. The advisory function of the Entomological Section at Pusa is of great importance in the present position of Economic Entomology in India. The section helps by determining crop pests reported by Provincial assistants, and advises regarding the methods of control likely to be effective in checking them. In several provinces these methods have been demonstrated on a large scale, as in the work against potato moth and surface caterpillars in Bengal, cane grasshopper and potato moth in the United Provinces and several pests in Madras. In Baroda State also, the Entomological Assistant keeps in close touch with Pusa, and has shown much practical energy. In the same connection, mention should be made of the arrangements made directly by the section for demonstrating the life histories and characters of injurious and beneficial insects. A considerable exhibit was

arranged for the Allahabad Exhibition; show cases, coloured plates with brief descriptive leaflets, and coloured lantern slides, were issued for demonstration and distribution to those interested.

Sericulture continues to form an important branch of the work. Eri silk production has been developed as a cottage industry in many parts of India, and received a great stimulus through the display arranged at the Allahabad Exhibition, and smaller exhibits shown at local shows in Bengal. The industry has been taken up by the Agricultural Departments of Bengal and the United Provinces. Difficulty is still experienced in disposing of small parcels of cocoons and thread, the mills being unwilling to buy except in large quantities. Experiments in mulberry silk production have been extended. Crosses were effected between European univoltine and indigenous multivoltine races, with a view to obtaining a robust multivoltine race, yielding silk of better quality than is produced by native forms. Broods of European mulberry silk-worms were successfully reared at Pusa, the resulting thread being well reported on by the trade. Experimental work forms only a part of the activities of the sericultural branch; a great volume of correspondence has arisen in connection with it, and arrangements for the supply of disease-free eggs, castor seed, samples of cloth and machines for spinning, doubling and twisting have required much organising. Twenty students from various parts of India attended the special course of practical instruction in silk culture during the year.

Lac culture was continued, and a practical training given to students in this subject. A large amount of material was collected, with a view to working out the races of lac insects in collaboration with Mr. Green of Ceylon, a specialist in the group.

Bees of two specially selected Italian strains were imported and an attempt is being made to acclimatise them at Pusa. Apiculture is still, however, in the experimental stage.

The study of the life histories of injurious insects has progressed, a number of important pests having been reared in the insectary and their habits studied. Mr. Ghosh has prepared a memoir on palm beetles, and Mr. Dutt on some Aculeate Hymenoptera. Other memoirs on life histories are in preparation.

The insect survey of India has been continued as time permits. Large collections have been sent for study by specialists, and to the authors of volumes of the "Fauna of India" series. Mr. Nowrojee has prepared a memoir on some aquatic insects.

The investigation of the damage caused by termites (white-ants), started by Mr. Lefroy in collaboration with Mr. Evans, Deputy Director of Agriculture, Northern Circle, Central Provinces, was continued by Mr. Fletcher. The latter officer was also invited to tour with the Railway Sleeper Commission, to advise on the best methods of reducing the enormous losses caused on Indian railways by these insects, and is carrying out experiments on the preservation of wood from their attacks.

8. *Second Entomological Section.*—This section is engaged in the study of Dipterous insects, and in particular those which suck blood and which may transmit disease. Mr. Howlett, who is in charge of it, only rejoined after absence on sick leave for a year and five months, towards the end of March, 1911. The work of the section was therefore practically in abeyance until the last quarter of the year.

Since his return, Mr. Howlett has had to devote much time to disposing of collections of material accumulated in his absence. The identification of these has progressed with assistance from the Indian and British Museums.

As special work, Mr. Howlett has been engaged in a study of parasites of Tabanidæ ("horse-flies"); the temperature reactions of mosquitoes, temperature apparently being one of the main factors controlling mosquito bite; the relative efficiency of the fish known as "Millions" and other enemies of mosquito-larvæ; and peach flies. In the

latter investigation a method of destroying the male fly, which is simple, cheap and effective, has been discovered, and though it seems improbable that anything short of netting the trees will completely prevent the female reaching them, the destruction of the males should very much reduce the damage done.

While on leave, Mr. Howlett attended as Indian delegate the First International Congress of Entomology at Brussels, and read two papers by Mr. Lefroy and himself. He also carried out, in collaboration with two other gentlemen, a successful series of experiments on the range and rate of flight of house-flies under natural conditions, points of importance in view of their behaviour as carriers of disease. The results were published by the Local Government Board in England.

Since his return, Mr. Howlett has again given invaluable assistance in supervising much of the work of the artist staff, and in advising the other sections in the preparation of illustrations for publication.

In certain respects the work of this section differs widely from that of the other sections at Pusa. It was founded to study Diptera, not only those (comparatively few in number) which are serious crop pests, but also those which convey disease to man and animals. Mr. Howlett's work is, therefore, closely related to the work of the Medical and Veterinary Departments, and it is probable, taking into account the great developments towards a realization of the importance of biting flies as disease carriers, that the activities of the Second Entomological Section will expand in this direction rather than on more purely agricultural lines.

9. *Bacteriology.*—Mr. Hutchinson held charge of this section throughout the year.

Much of his work has been of preliminary nature, confined largely to trial and selection of the bacteriological methods best adapted for dealing with the special conditions of soil and climate in India. The main lines have been aimed at determining under what conditions various

soils will best serve as culture media for those bacteria, naturally present in them, on which the processes of conversion of the organic nitrogen of humus into assimilable nitrates depend.

A special study has been made of the effect of hot weather ploughing on the bacteriological content of the soil, and the possibility of a bacteriological explanation of the undoubted increase in fertility resulting therefrom. It was found that the net result is an extremely rapid formation of ammonia, part of which becomes available to plants and part of which is lost. Depletion of the soil nitrogen is a necessary consequence and the maintenance of fertility must depend on the restoration of this by green manuring or otherwise.

A bacterial disease of tobacco occurring in Rangpur was investigated by Mr. Hutchinson. It was found to be caused by a strain of Bacillus solanacearum, an organism known to cause disease in several cultivated crops, such as potato, brinjal and tomato. The Rangpur strain differs from those described in America and Japan in some of its pathogenic features.

A disease of the Eri silk-worm, which causes havoc in the broods at certain times of the year, was also studied. It was found to be associated with the presence of bacteria in the intestine.

Certain preparations known as Ratin and Trope Ratin, prepared in Copenhagen, have been widely recommended as rat exterminators, and have been suggested for use in India, both with a view to checking plague and to protect crops against the ravages of field rats. Mr. Hutchinson carried out tests of these preparations. Ratin was found to have lost its virulence, but it is suggested that this might be recovered by preparation in India. Trope Ratin was found effective within a limited time after its preparation, but its cost precludes any possibility of its use on a large scale by cultivators. Neither can be recommended for employment at present.

Agricultural Bacteriology in the wider sense, including the bacteriology of industries dependent on agriculture, has made great strides in recent years, and developments in the practical application of this branch of agricultural science in the tropics now appear probable, which were scarcely anticipated when this section was founded at Pusa. Proposals are being made for strengthening the section, which is understaffed.

10. *Training.*—Two different classes of instruction are provided at Pusa. Students are admitted for a post-graduate training in the scientific sections, being ordinarily required to take up a single subject only. Exceptionally, to meet definite requirements of Provincial Departments, which are not in a position to train their own men for such positions as Assistant Director, Farm Manager and the like, post-graduate students have been admitted to a general course, including a period of study in each of the chief sections as well as practical work on the farm. Ordinarily, however, it has been held by the Board of Agriculture that students requiring a practical agricultural training are best provided for by the six Provincial Colleges, and now that these are all in working order, it is not anticipated that there will be much further demand for the post-graduate general course. The second class of instruction given at Pusa consists of short courses of an essentially practical nature in special subjects such as silk and lac culture, cattle and poultry breeding and management, and fruit growing. To these it is hoped to add dairying, for which there is a decided demand which we are not yet in a position to meet, while the course in tillage implements and agricultural machinery was discontinued during the year, as it was not fulfilling any useful purpose. Instruction is imparted in English or in the vernacular, and no educational qualifications whatever are required.

Of the post-graduate students, one continued his course in general agriculture, and one in entomology left after having finished his course during the year. Six students were admitted, two in general agriculture, two in chemistry

and two in entomology. The two students in general agriculture were recalled to their province after completing one year's training, as their services were required by the Provincial Department.

The short courses continue to be popular, students from all parts of India having been admitted. Four took up fruit growing; eight, cattle breeding and management; nine, poultry breeding and management; three, tillage implements and agricultural machinery; twenty, sericulture; and fifteen, lac culture. A certain amount of instruction in bee-keeping was given to some students interested in the subject, but as apiculture at Pusa is still in the experimental stage, regular courses have not yet been established. As far as possible, only those have been admitted to the short courses who propose to take up the subjects taught as a subsidiary means of livelihood to agriculture. In some cases, it was found that non-agriculturists sought admission in order to obtain certificates which would get them employment under Government, especially in Native States. Usually such students were not admitted, or if admitted, certificates were not given to them.

11. *Upkeep of the Estate.*—As a result of the floods, to which the low-lying portions of the farm are subject, and which resulted in a loss of over 100 acres of crops in July, 1910, the Public Works Department was requested to revise the arrangements for draining this part of the Estate, and in particular to repair and strengthen the protective embankments were defective. The flood referred to was probably the highest on record, and gave us a very anxious time, but the bulk of the protective works stood very well, and amply justified the outlay which was incurred on them. The repairs have been deferred pending allotment of funds; fortunately there has been no flood up to date this year.

Two additional blocks of quarters have been constructed departmentally for the use of the staff of the Inspector General of Agriculture, in continuation of those built last year. A new workshop and weigh-bridge for coal were

constructed in connection with the power-house, and plans have been prepared for a coal bunker. The ice plant has been fitted up and is now under trial. It is capable of turning out half a ton of ice in the day. An ice store is being built departmentally. The laboratories consume a good deal of ice which has formerly been obtained from Calcutta, and it is hoped that the new plant will not only prove a convenience but will effect an economy. Much trouble was experienced with the gas supply, owing to the retorts burning out. This culminated in a complete stoppage of gas for some weeks in the hot weather. The Oriental Gas Company of Calcutta kindly spared the services of their Chief Distributing Engineer, Mr. E. P. Reilly, to overhaul the installation. The laying of the retorts was found to be defective, and other minor alterations were carried out under Mr. Reilly's supervision, with the result that no further trouble has been experienced. We are under an obligation to the Company for their courtesy in sending up one of their best engineers to help us.

Provisional estimates for providing a Middle English School for the use of the staff of the Institute and the residents in the neighbourhood were sanctioned, the cost to be borne jointly by the Governments of India and Bengal. The estimates did not provide for residential quarters for the teachers; plans for the school and quarters were prepared with assistance from Mr. Preston, Inspector of Schools, Patna Division, and submitted with revised estimates for consideration by the Bengal Government. Some minor improvements were carried out in the students' hostel.

12. *Library.*—The revised catalogue of the library, corrected up to the end of 1908, was issued. The correction of the proofs and seeing it through the press entailed a great deal of work. The card catalogue was revised, and a register of new additions is now maintained in such a form that further editions of the printed catalogue can be brought out without much trouble. The loan arrangements are working admirably, and I am glad to note that

advantage is being more freely taken of the facilities for borrowing books given to officers of the Provincial Departments. The library is still wanting in many of the more expensive sets of periodicals; the sectional grants for purchase of books usually do not exceed 500 rupees; this is not more than sufficient for current literature, and there is no general grant from which expensive periodicals can be paid for. The new additions amounted to about 1,500 volumes. The library is rapidly becoming overcrowded and proposals for its extension are under consideration. The Director is in general charge of library arrangements and I wish to express my satisfaction with the work of Babu Anukul Chandra Chatterjee, the Librarian.

13. *Publications.*—The Journal, Memoirs and Bulletins were continued. As the Department expands, more work is submitted for publication, the Provincial Departments supplying an increasing volume of contributions. The grant for publications was reduced during the year, and transferred to the budget of the Inspector General of Agriculture. Much of the publication work is now done by the Inspector General, who is Editor in-Chief, the Pusa staff supervising the illustration work and also acting as an advisory committee. The free distribution list was considerably curtailed during the year, consequent on the reduction of the grant.

14. *General Health of the Station.*—The general health of the station during the year under report was good. Relief was afforded to 7,657 new cases, of which 7,477 were treated in the outdoor department, and 180 admitted as indoor patients. This is an increase of 1,426 cases over last year's total. The increase in attendance was due to the great prevalence of malarial fevers, and cholera, in the surrounding villages. One hundred and forty-six cases amongst European officials and families were attended to, an increase of 47 over last year's total. The daily average number of patients treated was 7·87 indoor and 49·05 outdoor, as against 6·96 and 48·97 respectively during the previous 12 months.

Four deaths occurred in Hospital,—two from malarial cachexia, one from Bright's disease and one from neglected hernia.

Two cases of cholera occurred amongst the families of the Indian staff in August, 1910, with one death. Immediate and successful measures were taken to prevent the disease spreading on the Estate.

One hundred and one surgical operations were performed: of which eight were major and the remainder minor.

The prevailing diseases were malarial fevers, *kala azar*, bowel complaints, rheumatic complaints and skin diseases. Blood diseases were diagnosed microscopically.

Quinine was issued prophylactically on the Estate towards the close of the monsoon.

Fourteen primary and ten re-vaccinations were performed in the early part of the year.

All drains in the building area of the Estate were made pucca during the year. A small cemetery was constructed departmentally. The number of residents within the Estate was over 700 on the date of the recent census.

15. *Accounts.*—The total expenditure incurred during the current year was Rs. 2,99,587, as against Rs. 3,12,427 of the preceding year. The principal items of expenditure are pay of gazetted officers and establishment Rs. 1,87,383, travelling allowance of officers and establishment Rs. 22,315 and farm expenditure, scientific apparatus, books, fuel, stores for electric and gas installation, contingencies, etc., Rs. 89,889. The grant for the "Agricultural Periodicals and Journal" has been transferred from this office budget to that of the Inspector General of Agriculture in India from 1st April, 1910.

The gross receipts during the year by sale of farm produce, milk and other miscellaneous articles, and Mr. Lefroy's book "Indian Insect Life," amounted to Rs. 13,462, as against Rs. 5,573 in the preceding year. Of this amount the sale proceeds of "Indian Insect Life" accounted for Rs. 5,490.

16. *Visitors.*—During the year under report the Hon'ble Mr. E. D. Maclagan, C.S.I., I.C.S., Secretary to the Government of India, Revenue and Agriculture Department, the Hon'ble Mr. F. C. Gates, C.S.I., I.C.S., Financial Commissioner to the Government of Burma, Mr. R. Inouye, Assistant Professor, Agricultural College of Tokio Imperial University, Mons. H. Brenier of the Commerce and Industry Department of French Indo-China, and Dr. Vermoesen, Mycologist Elect to the Belgian Congo, visited the Institute. Dr. Vermoesen worked in the Mycological laboratory for over two months at the end of the year.

Scientific Reports of the Agricultural Research Institute, Pusa

(Including the Report of the Imperial Cotton Specialist)

1918-19

REPORT OF THE DIRECTOR.

(G. A. D. Stuart, I.C.S., and E. J. Butler, M.B., F.L.S.)

I. Charge and Staff.

Charge. Mr. J. Mackenna, C.I.E., I.C.S., held charge of the office of the Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa, up to the 2nd October, 1918, and again from the 4th November, 1918, to the 12th April, 1919, when he proceeded on 6 months' privilege leave. Dr. W. H. Harrison acted as Agricultural Adviser and Director from the 3rd October to the 3rd November, 1918, and Mr. G. A. D. Stuart, I.C.S., assumed charge from the 13th April, 1919.

Dr. E. J. Butler, M.B., F.L.S., has been appointed Joint Director of the Institute, in addition to his duties as Imperial Mycologist, from the 20th January, 1919, and the appointment of the Assistant to the Agricultural Adviser to the Government of India held by Mr. Wynne Sayer, B.A., has been temporarily placed in abeyance from the same date.

Staff. Dr. E. J. Butler, M.B., F.L.S., Imperial Mycologist, was on deputation to the Federated Malay States, to report on the Agricultural Department there, from the

8th July to the 13th November, 1918. During his absence, Dr. F. J. F. Shaw, A.R.C.S., F.L.S., officiated as Imperial Mycologist, and Mr. J. F. Dastur, M.Sc., then First Assistant of the Mycological Section, acted as Second Imperial Mycologist. Mr. Dastur has since been appointed to the Indian Agricultural Service as Supernumerary Mycologist and deputed to England for fifteen months for training.

Mr. G. S. Henderson, N.D.A., N.D.D., was confirmed in the appointment of Imperial Agriculturist from the 1st March, 1918. On the termination of his temporary duties as Controller (Agricultural Requirements, Mesopotamia) under the Indian Munitions Board on the 22nd June, 1919, he proceeded on six months' combined leave. Mr. Wynne Sayer officiates as Imperial Agriculturist from the 20th January, 1919.

Mr. F. M. Howlett, B.A., F.E.S., Imperial Pathological Entomologist, was deputed for a period of 6 months from the 24th January, 1919, under the Indian Research Fund Association to conduct experiments with mosquito repellents.

Mr. J. H. Walton, B.A., B.Sc., on the termination of his duties under the Military Department, reverted to his appointment of Supernumerary Agricultural Bacteriologist on the 10th April, 1919. During Mr. Walton's absence of nearly four years he saw active service with the armies in Mesopotamia, Egypt and Palestine.

Captain W. Hodgkinson, R.E., worked in the laboratory of the Imperial Agricultural Bacteriologist throughout the year, in collaboration with that officer in electrical methods of water sterilization.

Mr. J. Sen, M.A., F.C.S., Supernumerary Agricultural Chemist, continued throughout the year on deputation under the United Provinces Government.

Mr. M. Afzal Hussain, B.A., M.Sc., who has been appointed to the Indian Agricultural Service, was posted to Pusa as Supernumerary Entomologist from the 6th January, 1919.

II. Work of the Institute.

Scientific work. The scientific work of the Institute during the year is described in the reports of the various sectional heads. The more important investigations were the following:—

On the Pusa farm, which is managed by the Imperial Agriculturist, besides carrying out manurial, rotational and varietal tests, the economics of steam cultivation are being studied. In view of the favourable reports of motor cultivation from home, a Fordson motor tractor was obtained during the year. A demonstration of its working was given in the presence of a large number of people from all parts of India. The tractor worked with implements in use on the farm and did all that it was asked to do in excellent style. Experiments are in progress to determine working costs, etc. The work on the breeding of pedigree herds of cattle is increasing in importance. Besides the pure Montgomery and half-bred Ayrshire × Montgomery herds, there are now three-quarter-bred, double cross-bred and quarter-bred calves on the farm. Careful observations and records are being kept with a view to collecting data as to hardiness, milk yield, etc., of the various crosses. A series of calf-rearing and feeding experiments are also in progress. During November, 1918, 169 cattle were inoculated against rinderpest by the serum simultaneous method, without any casualties. The demand for the surplus stock disposed of at the half-yearly sales was very brisk and high prices were realized.

In the Chemical Section, further investigation was made as to the value of Dyer's method in estimating available phosphoric acid when applied to calcareous soils. Attention was also directed to the retention of phosphoric acid in calcareous and non-calcareous soils. The influence of windrowing on the sugar content of sugarcane in the Peshawar valley and the direct and indirect action of green manures in relation to paddy cultivation were other important investigations in progress in this Section.

Besides creating new centres of distribution of Pusa 12 and 4 which are now preferred to the country wheats wherever they have been introduced, the Botanical Section reached during the year an important stage in the breeding of rust-resistant wheats. Many new forms which are characterized by strong straw, rust-resistance, good standing power and heavy yields have been fixed, and these are being tested on a field scale. The Howards' experiments in water saving in wheat growing have shown that if the texture of the soil has been improved and if the surface has been properly graded, extremely heavy crops are possible with a comparatively small volume of irrigation water. The agricultural side of the indigo problem continued to be studied in this Section. The effect of drainage on crop production and the pollination of Indian crops were some of the other lines of work on which Mr. and Mrs. Howard were engaged during the year.

The Ufra disease of rice, the black band disease of jute, sugarcane smut, the pigeon pea wilt and the diseases of chilli principally engaged the attention of the Mycological Section during the year under report. The various diseases affecting fruit trees are also under study in the orchards in the Kumaon hills, and spraying experiments are being carried out both there and in Peshawar.

In the Entomological Section, besides working in determining the relative immunity of certain varieties of cotton from bollworm attack and studying the borer pests of sugarcane and other graminaceous plants, special attention was paid during the year to the collection of information regarding fruit-pests. It has been ascertained that the "Tukra" disease of mulberry is caused by a mealy-bug, and that the affected apical leaves if fed to mulberry silkworms assist in inducing flacherie. The enquiry regarding the occurrence in the Indian Empire of any insects which may be used as efficient checks on the growth of *Lantana* was completed during the year and the results are being published separately. The work in connection with bees, lac and silkworms was continued.

Practically throughout the year, Mr. Howlett, Imperial Pathological Entomologist, was on special duty in connection, firstly, with the prevention of surra-transmission by Tabanidæ, more particularly among transport camels, and, secondly, with the improvement of existing culicifuges for military use. Reports on the work in these two directions have been submitted to Government.

Problems of soil biology under investigation in the Bacteriological Section during the year under review were:—(1) Seasonal variations in nitrification in soils under crop and fallow; (2) different rates of nitrification of various organic materials in soil; (3) inhibition of nitrification by toxins resulting from anaerobic incubation of soils; (4) green-manuring; and (5) fixation of nitrogen by legumes. Among enquiries of industrial value, Mr. Hutchinson, besides continuing his work on indigo and the pebrin disease of silkworms, succeeded during the year, in collaboration with Captain Hodgkinson, in producing a solution containing 3-4 per cent. available chlorine by electrolysis from purely Indian raw materials, for the sterilization of water. The solution can be prepared anywhere where electric current is available without expert knowledge either of chemical or electrical methods.

The work done by the Indigo Section is published in a special series of Indigo Publications started by the Institute. A separate annual report has therefore not been considered necessary.

Training. A number of post-graduate students attended the Institute during the year and short courses were given in sericulture and lac-culture:—

	Number of students.
General Agriculture	2
Agricultural Chemistry	1
Mycology	2
Economic Entomology	2
Agricultural Bacteriology (including bacteriological technique in silkworm disease)	2
Sericulture	4
Lac-culture	2
TOTAL	15

Besides the regular students, Mr. S. N. Bal, Assistant Professor of Botany, Science College, Calcutta University, spent about a fortnight in the Mycological Laboratory in March and April as he proposes to take up mycological work in Calcutta.

III. Publications.

Six Memoirs, 13 Bulletins (including three reprints and one vernacular version), and three Indigo Publications were issued during the year, while ten publications were in the press at the close of the year.

The demand for the Bulletin on "Insecticides, Mixtures and Recipes for use against Insects in the Field, the Orchard, the Garden and the House" continued, with the result that it had to be printed a third time during the year. A Bengali version of Bulletin No. 46 on Bee-keeping, written in language simple enough to be understood by the village folk when read by themselves or read out to them, was issued during the year and the whole edition rapidly sold out.

The Agricultural Journal of India in its new form continues to gain in popularity, and it became necessary during the year to increase the print order by 250 copies. It is proposed to issue the Journal bi-monthly, instead of quarterly, with the commencement of the New Year. All the present features will be maintained, but no increase will be made in the annual subscription.

IV. General Administration.

Buildings and works. The bungalow for the Electrical Engineer referred to in last year's report was completed during the year. The construction of quarters for the First Assistant to the Imperial Mycologist as well as for the staff of the Pusa High English School will be begun as soon as the necessary materials are available. Necessary funds have also been allotted for the construction of a building for the Post Office and a rest house for Indian visitors. A pumping set has been installed on the river

Gandak to tide over the period until a more satisfactory scheme of irrigation can be worked out.

Library. In addition to the 1,656 bulletins, memoirs, reports, books and reprints received in exchange, 457 new volumes were purchased during the year. A fourth edition of the catalogue of the library is in the press.

Pusa School. The total number of pupils attending the Pusa High English School on the 30th June, 1919, was 192 as against 160 on the corresponding date of last year. Of the 11 students sent up for the Matriculation Examination of the Patna University, seven were successful.

General health of the station. Although the neighbouring villages suffered severely with the rest of India from the influenza epidemic, it was noteworthy that the number of cases on the Pusa estate were relatively few and there was not a single death. This was not a little due to the precautionary measures taken by the Medical Officer, Mr. S. Gupta, and his staff, who deserve great credit. Medical relief was afforded to 19,938 out-patients and 203 in-patients in the hospital and dispensary attached to the Institute during the year under report.

V. Accounts.

The total expenditure during the financial year 1918-19 was Rs. 6,06,640, as against Rs. 5,81,723 during the previous year. The details are given below:—

	Rs.
Office of the Agricultural Adviser and Director	2,35,301
Chemical Section	38,129
Mycological Section	42,954
Entomological Section	55,073
Pathological Entomological Section	38,131
Bacteriological Section	32,860
Botanical Section	50,327
Agricultural Section	63,594
Indigo Research Section	50,271
Total	6,06,640

A sum of Rs. 15,000 was paid as a grant-in-aid to the Indian Tea Association.

The principal items of expenditure under the annual grant of Rs. 10,000 placed at the disposal of the Agricultural Adviser to the Government of India for special agricultural experiments were as follows:—

	Rs.
Purchase of a corn crusher	655
Purchase of a chaff cutter	596
Purchase of canvas paulins for the Pusa Farm .	652
Paid to the Director of Agriculture, Bengal, for the cost of a mechanical fibre extractor . . .	1,457
Experimental cotton cultivation by the Imperial Cotton Specialist	1,200
Pay of a Veterinary Assistant in connection with cattle breeding and that of a Fieldman for mosquito experiments	1,431

The gross receipts during the year from the sale of farm produce, milk, publications of the department and other articles amounted to Rs. 21,403 as against Rs. 19,843 in the previous year.

VI. Conferences.

The Government of India having accepted the recommendation of the tenth meeting of the Board of Agriculture in India held at Poona in 1917 that sectional meetings of mycologists, entomologists and chemists be held in years in which there is no meeting of the Board of Agriculture, such meetings were held at Pusa in February, 1919. In accordance with the recommendation of the Board, they were not confined to members of the Agricultural Department. The Indian Tea Association and Portuguese India were represented at both the Mycological and Entomological Meetings, whilst the Forest Zoologist attended the Entomological Meeting. The latter meeting also attracted visitors from outside India, the Egyptian Government sending an official delegate in Dr. Lewis H. Gough, Director of the Entomological Service in Egypt, and Mr. R. Senior-White attending from Ceylon. Detailed proceedings of these meetings are being issued.

A cattle conference was also held at Pusá during the year, when several problems connected with the Pusa dairy herd were discussed.

VII. Visitors.

The most notable visitor during the year was His Excellency the Viceroy. This was the first time that the Institute was honoured by a visit from a Viceroy. Lord Curzon had previously visited Pusa, but he came only to lay the corner stone of the splendid building which houses the various laboratories of the Institute. His Excellency Lord Chelmsford, who was accompanied by the Hon'ble Sir Claude Hill, Member in charge of the Revenue and Agriculture Department, spent three busy days (4th to 6th January) in going over the various Sections and evinced much interest in all that he saw.

In all about 165 ladies and gentlemen visited the Institute during the year. These included :—

Lieutenant-Colonel F. H. G. Hutchinson, M.B., I.M.S., Sanitary Commissioner with the Government of India; Dr. C. A. Bentley, M.B., D.P.H., D.T.M. & S., Sanitary Commissioner to the Government of Bengal, Mr. P. J. Hartog, C.I.E., M.A., B.Sc., L-es-Sc., Academic Registrar of the University of London and Member of the Calcutta University Commission; Professor C. V. Raman, M.A., Palit Professor of Physics, Calcutta University; Mr. A. B. Shakespear, C.I.E., of Messrs. Begg Sutherland & Co., Cawnpore; Mr. G. E. C. Wakefield, O.B.E., Director General of Industries, Agriculture and Commerce, Hyderabad (Deccan); Lieutenant-Colonel Milton, Assistant Director of Grass Farms, Meerut; Lieutenant-Colonel J. Matson, Assistant Director of Military Farms, Northern Circle, Ambala; Major V. B. Nesfield, F.R.C.S., I.M.S.; Captain Froilano de Mello, Director of the Bacteriological Laboratory, Goa, Dr. L. H. Gough, Director of the Entomological Service, Egypt; Mr. S. Higginbottom, Director of Agriculture, Gwalior; Mr. C. F. C. Beeson, M.A., Forest Zoologist, Forest Research Institute, Dehra Dun; Mr. J. C. Nag, Senior Professor of

Botany, Presidency College, Calcutta; Mr. E. A. d'Abreu, F.Z.S., Curator of the Central Museum, Nagpur; Mr. C. C. Monckton, of Nairobi; Mr. R. Senior-White, F.E.S., Matale, Ceylon; Kumar Chandreswar Prasad Narayan Singh of Sursand and Syed Shafael Hussain of Gaya.

Among other visitors were officers of the various Provincial Departments of Agriculture, and planters and zamindars of estates surrounding Pusa. A party of students from the Sabour Agricultural College, under two Assistant Professors, also visited the Institute during the year.